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THE LIGHT SIDE OF SCIENCE

THE
LIGHT SIDE OF SCIENCE

BY

ANDREW WILSON

Author of " Chapters on Evolution," " Studies in Life and Sense,"
" Leisure Time Studies," &c., &c.

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To

R. D. ROBERTS, M.A., D.Sc., ETC.

Secretary to the Gilchrist Educational Trust

IN REMEMBRANCE OF LONG FRIENDSHIP AND
PLEASANT ASSOCIATIONS

Prefatory Note

I HAVE not even the customary author's apology ready by way of excuse for the publication of these desultory papers. But if, perchance, my idea is correct, that they may interest folks who like their science treated with a light touch, I need go no further afield in search of an apology for my daring—unless, indeed, it may be that happy memories of summer days and other days, spent by the sea and elsewhere, have incited to this garnering of "the harvest of a quiet eye." My thanks are due for permission to republish the substance of this volume in book-form.
A. W.

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CHAPTER I

Some Curiosities of Breathing

Breathing and its automatic nature — The true nature of respiration — Ancient errors—The constitution of air — Carbonic acid gas and its Story—Mechanisms of breathing —Gills and lungs—Their respective functions in fishes.

THE fact that our chests rise and fall fifteen or sixteen times a minute in the act of respiration or breathing is so familiar that it almost escapes popular recognition through its practically automatic continuous nature. Breathing is one of those actions, which, while absolutely essential for the maintenance of life, and which, performed for the most part unconsciously, yet lie somewhat under the control of the will. Physiologists call breathing a secondary automatic action, in order to distinguish it from those functions of the body with which we cannot interfere. The duties of digestion, the making of bile, the formation of saliva, the flow of tears, the expansion or contraction of the blood-vessels—are acts which proceed independently of our will and consciousness, and they are undoubtedly performed all the more perfectly in that we have no need to concern ourselves about them at all.

So much of life is thus truly machine-like in its nature, this unconscious regulation of the necessary duties of existence is of great advantage to us because our intellectuality is left free, as it were, to concern itself about more important affairs. Life would, in truth, be far too short for all we have to do in the way of mental work, if we had to think about everything the body wants and requires for its purely physical maintenance. Among the acts, however, which are vitally necessary we rank breathing (or respiration) as one of the chief. That "the breath is the life" is a very old saying, and one no doubt founded, as regards its origin, on the obvious need for air, and on the disastrous consequences which ensue when animal life is deprived, even for a very short time, of its atmospheric supply. Yet, like all other great discoveries, the true nature of the "breath" was only arrived at after centuries of speculation and doubt, and after much laborious experimentation into the nature of the processes which breathing may be said to include.

One ancient idea, certainly as old as Aristotle himself, was that which held the real purpose of air introduced into the body was to cool the blood. Another curious and noteworthy idea supervened on this first notion of the uses of breathing. The arteries or blood-vessels, which carry pure blood from the heart all over the body, were found then, as now, empty after death, and the classic physiologists, imagining that this empty condition represented the natural state of the vessels, held that their duty was to carry the air inspired in breathing to cool the blood. The very name "artery" is derived from the Greek equivalents for "holding air." The veins were known to contain blood on the other hand, and it was therefore believed by the old physicians that they represented the means whereby the vital fluid was really circulated through the tissues.

Needless to say, in those classic days nobody entertained any clear ideas about the circulation of the blood. It was not known that while the arteries carried pure blood from the heart, the veins were really continuous with them, and brought back to the heart, the arterial stream laden with the waste products of the bodily wear and tear. Such knowledge was reserved for a later time, when William Harvey completed the edifice others had assisted in founding, and showed how the double heart of man and his neighbour-animals had reference to the two-fold duty of sending out pure blood to the frame and transmitting impure blood to the lungs, there to be purified and renewed.

Naturally the study of lower animals helped the understanding of human functions in this and in other respects. Breathing, instead of being found to be a purely human process, was seen in time to be represented universally in the domain of animal life. Somewhere about 1776 Priestley showed that, so far from air being one of the "elements," it was composed of two gases, existing not in a state of chemical combination, but in a mere condition of mechanical apposition.

The air is not a compound, in other words, but a mixture of two gases. One of these is oxygen, which may be termed the great supporter of the flame of life. It is the so-called "vital" gas, for without it none of the actions involved in the maintenance of life are possible of attainment or execution. The other gas, far exceeding the oxygen in point of bulk and quantity, is nitrogen. It is what physiology calls an inert gas, because it appears to have no action whatever on the animal frame. In other shapes nitrogen becomes an important constituent of the animal body, as, for example, when it forms part and parcel of certain foods. Nay, more, it is one of the elements which is inseparably connected with living matter itself. But when it is represented in air its only use or service seems to be that of diluting the oxygen, since the nitrogen goes into and passes out of the lungs practically unchanged. Therefore it is clear that the oxygen is the element in the atmosphere without which animal life would become non-existent. We might, indeed, go further afield still and affirm without any fear of scientific contradiction that for plant life itself, oxygen is also a vital necessity.

Very closely connected with the essential features of breathing is the removal of so much of the body's wear and tear, to which a passing allusion has already been made. From the lungs are given forth carbonic acid gas, water, heat, and other waste products, which are undoubtedly brought to the lungs by the return current of blood in the veins. The skin also gives off so much of the bodily waste, and the kidneys likewise represent organs devoted to the work of waste removal. In fact, lungs, skin and kidneys (and to a certain extent the liver) form a kind of physiological trio engaged in the all-important duty of securing the body's freedom from the consequences of its work and wear.

Now, it is the carbonic acid gas, which is chiefly got rid of by the lungs of animals, that forms in one sense the physiological opposite of the oxygen breathed in from the air. Truth to tell, the oxygen assists in the production of this waste gas, which really represents the ashes of the bodily fire. All parts of the living tissues absorb oxygen as part and parcel of their food-wants. In this respect it is the same in the animalcule as in the man. Taken as part of its nourishment, the oxygen enters into combination with the living frame. Then, when that frame discharges its duties, the result of the work, in part, is given off in the shape of the carbonic acid gas, which is itself an undesirable surrounding for animal life, and which entails ventilating schemes to get rid of it in higher existence. It might be shown, if necessity existed for the demonstration, that plants also respire, in the sense that they demand oxygen and give out carbonic acid gas. The long and the short of it is that for all life oxygen is a necessity, and that there occurs the universal discharge of carbonic acid gas as the practical result of vital work everywhere.

But, having regard to the method in which breathing may be performed, we light upon great variations when we come to consider that function in different animals. Some are water-breathers like the fishes, others air-breathers like man himself, while others again (like some members of the fish and of the frog classes) unite in themselves both styles of respiration. The phrase "water-breathers," it should be remembered, is itself anomalous, and in part erroneous, for it is always air which is inhaled and never water.

The fish does not differ from the man in respect of its respiration; both breathe air, and the only great difference between them is that the one obtains the air which is mechanically suspended or entangled in the water, while the other inhales the air-supply directly from the atmosphere. A gill and a lung really resemble each other closely and exactly in so far as their essential structure is concerned. Each consists of a network of fine blood-vessels, through the walls of which the air passes inwards to the blood, while the effete and waste matters conversely pass outwards to the surrounding atmosphere or water.

The mechanisms of breathing in fish and man alike are simply directed to insure that a constant supply of air shall reach the network of vessels in the breathing-organs, and that a free exit for the carbonic acid gas shall at the same time be afforded. To call one animal a "water-breather," and another an "air-breather," is therefore to mistake the essential terms of respiration. It is merely a difference of detail which has to be considered, and not a fundamental variation in the respiratory work. Indeed, from the point of view of recent researches into the manner of breathing in the two classes, it would appear as though the variation which does exist, was in further need of being abolished altogether.

Dealing with breathing from the standpoint of comparative anatomy we gain great help from the researches of Professors Wilder and Gage, of the United States, in the endeavour to understand the part which is played by gills and lungs respectively in the respiratory work. A long and laborious investigation, first of all, taught these accomplished observers that in the case of a fish (such as the mud-fish) provided with both gills and lungs it was not correct to assume, as had been before supposed, that each of the breathing organs in the animal discharged the same amount of work. Both undoubtedly act in the same way—both inhale air and give off waste carbonic acid gas—but a difference in degree is clearly perceptible. Now, carefully watching the breathing process in such a fish, and noting the relative amounts of waste products given forth from gills and lungs, Professors Wilder and Gage arrived at the conclusion that where two sets of breathing organs (gills and lungs) occur in one and the same animal, the gills are chiefly devoted to giving out carbonic acid gas, while the lungs, conversely, are chiefly occupied with taking in the oxygen-laden air. It is as if a physiological division of labour was thus organised in these double breathers, and, as we shall presently note, even in some animals in which there exist lungs alone, a kindred specialisation of the breathing-work has to be taken into account in estimating correctly the manner of their respiration.

When exact figures of the amount of oxygen taken in from, and of carbonic acid given out to, air and water respectively are discussed, this interesting view of matters is seen to be confirmed. In the double-breathing fish, for instance, the oxygen taken from the air amounted to 65 (cubic centimetres) and from the water to 10; and while the carbonic acid given to the air was only 22, that given to the water was 53. In a bull frog, in which the skin alone represents the water-breathing organ, and thus corresponds to gills, the oxygen taken from the air was 183 and from the water 4, the carbonic acid given back to the air being 110 and to the water 77. The frog is typically a lung breather of course, but it is most interesting to find the proportions between the air and water breathing, as above recorded, so close.

Much more distinct was the case of a soft-shelled turtle (*Amyda mutica*). This animal, like all reptiles, breathes by lungs alone; yet, being a water-liver, it has apparently acquired a faculty for the fish type of breathing. For in these animals it appears that the throat parts have come to discharge gill-like functions in respect of getting rid of carbonic acid gas. They remain submerged for long periods, and their lungs are relatively large. What happens with the turtles, then, is that a full supply of air is taken into the lungs when the animal comes to the surface. This air is slowly used up in the processes of life, and the carbonic acid gas is discharged chiefly by the throat-membrane, which latter surface also absorbs oxygen, though in a limited degree. The figures for the turtle are:—Oxygen absorbed from the air, 31, from the water, 8; and carbonic acid given forth to the air, 10, and to the water, 77.

Equally interesting is it to note that, among the frogs and newts, we get animals which begin life as tadpoles breathing by gills alone. As they pass onwards to the adult stage of things, they shed their gills and develop lungs. In some members of the frog-class, of course, we find animals breathing by gills and lungs together throughout life. Also, and more extraordinary still, there is at least one species of Siren or American newt which loses its gills when it gets its lungs, and then redevelops gills, that it may more perfectly pursue an aquatic life. Now, as Professor Gage reminds us, we are here face to face with a very pretty problem, to which evolution supplies the key. Why this need for the two types of breathing, say in animals which possess lungs alone, and which we might naturally think had got rid of their water-living habits in the far back past?

The answer to this question is found in the plain fact that to deposit their eggs, and in many cases even to find food, these animals (represented by the frogs, turtles, and others) resort to the water. Existing thus for lengthened periods under the water, we find a return as it were to the old and primitive water life of their ancestors. For that they have all descended from water-living progenitors, is clearly proved by the young being provided at one stage of existence or other with gills. The need for being able to live easily under water, in other words, has given rise to the development of the aquatic type of breathing.

This is a very satisfying demonstration indeed of what a reasonable school of thought maintains is the cause of change and variation in animal existence—namely, the requirement for a special mode of life acting as the stimulus to the supply of that want. Higher life, too, knows this stimulus well. It is a natural, and also a just idea, that human life can only be well and thoroughly lived out when our powers of living correspond to the wants and demands which are made upon them.

CHAPTER II

Earth-Tremors, New and Old

Religious Journals and "Prophecy"—The astronomical idea of the world's end—Earthquakes and land-movements inevitable—Hope for the British Isles—The Temple of Jupiter Serapis and its curious history.

EVERY now and then, everybody who "reads the papers" is duly informed that certain inhabitants of the British Islands (and other parts adjacent to the Greater and Lesser Cumbraes) have experienced the effects of an earthquake-shock. County Wicklow and Bristol, for example, were affected not so very long ago, although we did not hear of that seismic centre in Perthshire, Comrie by name, having been equally disturbed with the southern parts of the land. Truth to tell, we are not much given to be shocked at all in a worldly sense. Now and then we get a slight reminder that the earth is a cooling and a shrinking globe, and subject to the little disturbances incidental to the condition of an expiring or waning orb.

The good old moon, of course, knows naught of shocks, because she is devoid of heat altogether: though doubtless time was, judging from the eruption of volcanoes on the face of her which is next us, when she suffered greatly from the cosmic fever like unto that which affects our own world. There are, I believe, certain "religious" journals—I know of one at least—which do not a little, but a good deal of business in the prophetic line. I don't know how many events have been prophesied in one such newspaper, but which, alas! have never come to pass—including various speculations founded on the Number of the Beast, and other delightfully vague but inspiring details.

The end of the world has always been a favourite theme with prophets of this type. People, you see, are always anxious to keep a little ahead of the times, and even a worldly speculator might feel interested in knowing how long he might be permitted to plunge financially, or whether he might stay his hand from "bulls" and "bears," and calmly await the end of all things. This is the great secret of the attraction which prophecies have for the multitude. "To peep with security into futurity, sum up a history, clear up a mystery," as Mr Gilbert puts it in *The Sorcerer*, is a gift everybody envies, from the gentleman who wants to know "a safe thing" for the next big race, to the Sherlock Holmeses in the flesh themselves. It is, besides, a decidedly safe game this of playing at prophets in a cosmical sense.

For most people have short memories, and if you predict the end of the world in, say, 1910, your clients will probably have forgotten all about your prediction long before the 31st December 1909 arrives, and you can easily dose them over again with a later date, and thus keep the ball rolling without much or any detriment to your prophetic reputation. There is one little disadvantage, however, which accrues to the modern soothsayer with his weekly penny-a-number illustrated prophecy paper, and that arises from the fact of science (which, like Hosea Biglow, only prophesies when it knows) being able to discount the idea of the world coming to an end at all in the manner popularly believed of the "religious" editor.

If what astronomy teaches us be true, the end of our orb will not be a grand cosmical catastrophe of incandescent nature, but a much milder form of extinction. It will take things coolly, very coolly, because in fact it will lose all its heat, and become a cold, waterless, airless, and therefore a lifeless body, like the moon herself. This is the astronomical idea of a world's end, or at least of the ending of an orb with the constitution of our own. We shall get "pegged out," as the schoolboys say, not from over-heating, but from want of heat; and when the final stage of cooling arrives we shall cease troubling about volcanoes and earthquakes, and every other form of cosmical unrest, and will close our accounts as a planet in the blackness of a burnt-out world.

As things are at present, however, we are perpetually being shocked by earthquake waves. When I say perpetually I use the word in its literal sense.

For be it borne in mind that there are earthquakes and earthquakes; and that these disturbances vary in intensity from the merest tremor of the ground to the big catastrophe that lays a city in ruins, drives back the sea to swamp the land next moment with a watery avalanche, entails death and destruction for leagues around, and affects districts thousands of miles away.

Let us put the matter in another way, if you please. Earthquakes do not stand alone in the list of the actions which have operated on the world from all time past, and which are operating on and fashioning and sculpturing it now. They are part and parcel of the same force or agency which is seen equally in slow movements of land and in the formation of volcanoes; and all three things—the land movements, the volcanoes, and the earthquakes — owe their being to the earth's internal heat. This is mere matter of ordinary knowledge no doubt, but it forms the foundation of the understanding of many of our world's little ways all the same. If anybody is anxious to know why the earth should be hot inside, this also is a matter easily to be explained. For the world has a heated interior, because it once was all hot, and has only cooled down sufficiently in the course of a trifling few millions of years to permit its baked crust to be suitable for the abodes of men. Its present limited heat is the remnant of its once universal heat when it was in the sun-stage of its history.

As we have seen, when it loses all its heat and cools down completely, it will have arrived at the end of its tether, which is of course the moon-stage of things. Therefore, between the slow movements of the earth's crust which are always taking place and the big earthquake there is a real bond and connection, because they are actions which differ not in kind but only things are lively in degree. When underneath us, and a big store of energy is developed in the lower crust of the world, and when this energy is liberated, and finds its way to the surface, we get one big shock, with all its destructive effects. But when cosmical business is a bit dull, and when there is not much doing beneath in the underground vaults, we have perforce to be content with our small trifling shocks, or with the more or less constant changes in land level to which I have alluded.

It is these latter changes which are perpetually going on around us. They are really slow and gradual earthquakes, through which the heat-forces below show their spirit of unrest, and which they practice on the world's crust as if to keep their hand in for occasional long displays. This is the whole philosophy of earth-movements in a nutshell. Quite true, there may have been a good many more earthquakes of big magnitude in the past than have happened in the recent history of the world, even admitting that we have done quite enough in that way, or more than enough, since human history made its first start in life. Possibly the world is getting sobered and settled down, and not so much given to playing pranks as in the more impulsive days of its early youth. Be that as it may, it is quite within the range of possibility we may be shocked cosmically, often and severely, before our planet is very much older. There is one comfort, however, for the Greater and Lesser Cumbraes and the adjacent islands—namely, that as we have a goodly number of volcanoes round about us in Europe, these outlets for the heat-activity may save us from any nigh prospect of damage and disaster near at home.

Lately I happened to light upon an account of Mr C. Babbage's famous description, written in 1828, of the land-movements which were associated with a certain famous temple on the Bay of Naples. This account presents to us a most excellent illustration of the nature of the land-movements which, as we have seen, are practically one in kind with earthquakes themselves. To the west of Naples lies the Bay of Baiæ, which is literally fringed with volcanic craters. To the north-west of the village of Puzzuoli, situated in the middle of the bay on a kind of promontory, stands Monte Nuovo, which was built up in some twenty-four hours by a volcanic eruption so recently as 1538.

A little bit to the east lies the Solfatara, an expiring volcano emitting horribly suffocating vapours as a kind of cosmical protest against its death. Then back from the bay is Monte Barbaro, with, how ever, its flanks reaching almost to the waters of the sea. Around the bay are the Phlegræan Fields of classic fame, wherein the entrance to Pluto's domain was erstwhile laid. This is the general lie of the Baiæ district, and close to the water's edge at Puzzuoli stand the ruins of the temple of Jupiter Serapis. Now, in the *Acta Petri et Pauli*, a work which is believed to date from the fifth century, we read as follows:—"And Paul being in Pouteole (Puzzuoli), and having heard that Dioscerus had been beheaded, being grieved with great grief, gazing into the height of heaven, said, 'Oh! Lord Almighty . . . punish this city, and bring out all who have believed in God and followed his word.' He said to them, therefore, 'Follow me.' And going forth from Peuteole . . . they came to a place called Baias (Baiæ), and looking up with their eyes they all see that city, Peuteole, sunk into the seashore about one fathom, and there it is until this day for a remembrance under the sea." So far the *Acta*.

Clearly, as has been remarked by Dr R. D. Roberts, it is evident when these last words were written the town of Puzzuoli was and had been under water for a very long period. What had actually occurred was not an event which came under the notice of the writer of the *Acta*. Tradition of the miraculous subsidence of Peuteole had replaced what we know to have taken place on the Bay of Baiæ; and if the *Acta* date from the fifth century, then we may first of all place the date of the land-movement we are about to chronicle as early as the fourth century, or probably in the third.

What we see at the temple of Jupiter Serapis are broken columns and walls, and three marble pillars, each about 40 ft. high, still standing. Up to 9 ft. high the pillars are solid and uninjured. Then comes a limy coating extending to about a foot in height. Next a clear space, about 17 in. deep, and above this again, for a space of 8 ft. 2½ in. or so, is a zone, eaten into by the burrowing shellfish, which there, as here, bore their way into rocks as habitations. Near the top of this shellfish zone is a slight mark, showing probably that for a time the water-level remained at this height.

Now, how did the shellfish reach the pillars? for that the holes were bored by these animals is proved by the fact that you may still find the shells in their burrows. Either the sea came up to the pillars, which is a ridiculous supposition, involving a big, impossible, and permanent rise of the whole Mediterranean, or the pillars went down to the sea. Which thing will you choose? Clearly the second, which is consistent with all we know about land-movements, and still more consistent with the chronically-disturbed constitution of the Bay of Baiæ itself. Begin, if you will, with the significant fact that below the marble pavement from which the pillars rise, there is another pavement existing at a depth of 5 feet.

This proves that when the builders of the temple had begun their work they were troubled by the sinking of the land. Their foundations were carried down below the level of the sea, and their labours were thus made of none effect. Then came a period of rest, and the temple was erected. Suppose, what is highly probable, that the building was completed during the second century (a fact proved by inscriptions on its walls detailing that precious marbles were gifted to it by Severus in the years 194 A.D. and 211 A.D., and again between 222 and 235 A.D.), then, between the last-named year and 1750, when the ruins were discovered and excavated, the land must have sunk to a distance of at least 20 feet. The course of events, as we know, began, before the erection of the temple itself, with the sinking of the first marble pavement.

There were intervals and breaks in the process of subsidence. It was a spasmodic and interrupted, and not a regular sinking. The limy incrustation at the lower part of the pillars, no doubt, arose from the mingling of the sea water with the waters of the hot springs which arise within the limits of the temple itself. Then the Solfatara sent down the next layer of volcanic ashes; then came another incrustation of lime, and next another Solfatara contribution of volcanic *debris*. So that we account for some 10 or 12 feet of covering for the lower parts of the pillars, leaving, after a further rapid sinking, a space above, free in the water for the young shellfish to fix on the pillars as habitations and to bore their way into the stone. The upper 20 feet or so of the pillars remained above water, and this extent later on was itself covered up with volcanic rubbish, and possibly also with materials washed in by the sea. So that when, in 1750, the Italian antiquaries set to work to excavate the ruins, only a few feet of the pillars remained above the soil which had been heaped up upon them by wind and sea and volcano.

This is the story of one famous land-movement, which is really itself a piece of earthquake-motion. We get a little further light in this strange history from the fact that a certain deed, dated October 1503, tells us that a grant of land was made to the University of Puzzuoli, and a later deed bears date about 1511. These deeds refer to land where it was alleged the sea was drying up or had dried up—a mistaken idea, as we have noted, for the sea never alters, while the land is perpetually the child of change. In 1503, therefore, the sinking of the land had ceased, otherwise the benefaction to the University would have been of none effect; and in 1538, when Monte Nuovo came into existence, the sea was described as having retreated from the coast. It was a case of the coast having risen from the entrance of the sea, owing, doubtless, to the effect of the volcanic outbreak.

Our thoughts go back to the third or fourth centuries, however, as the time when this little drama of cosmical action was played out in its chief details;

and these same thoughts lead us in an unbroken continuity to the present time, when we read of earthquake-shocks and earth-tremors, one in kind, and different only in degree from the exhibition of energy which laid the old temple on the Bay of Baiæ in the grasp of the waves.

CHAPTER III

Co-operation in Lower Life

"Sea-flowers"—Their truly animal nature—Co-operative colonies for mutual aid—Their method of reproduction—Variations of the plan—Co-operation on higher planes.

SITTING by the seaside this fine spring afternoon—herald, I trust, of many fine days to succeed it—I note amidst a mass of sea-wrack cast up by the waves a set of curious plant-like things which my friends the fishermen in the village beyond call "sea-flowers." They, at least, know the "sea-flowers" well. They come up in great masses in the dredge, and on their lines they are also found, sometimes in such quantity that the worthy men growl and grumble at the task of freeing the lines from the encumbrances of the sea.

The "sea-flowers" you may know under another name or aspect. In sea-coast towns it is the custom to sell baskets of shells decked out with these productions of the deep. The "flowers" are stained and dyed in various hues, and very pretty ornaments indeed they make, in all their feathery grace and lightness. If you have ever gone dredging for oysters, you will know the "sea-flowers" well; for well-nigh every oyster you bring up has these organisms growing upon its shell.

The common type is that you see in the wrack before us. Each "sea-flower" is about three inches or four inches high. It has a stem and branches, and as the branches in the species before you are given off with symmetrical regularity, as in the fir tree, you cannot wonder that the name "sea-firs" has been given to the "sea-flowers," from their likeness to the denizen of the forest. Now, what the fishermen call "sea-flowers," and what people who collect sea weeds stick in their albums as samples of marine plants, are not plants at all. Like many another living thing they have suffered from their likeness to the plant world at large. They are, in reality, animals, possessing all the ordinary features and belongings of animal life, and yet growing rooted and fixed in the strange and striking verisimilitude of the plant.

Popularly, to readers possessing a certain amount of zoological knowledge, the sea-firs are known as "zoophytes"—rather an unfortunate name, because, if we elect to hold by its derivation, it would indicate that our sea-flowers are half animals and half plants. Nothing of the kind is represented in sea-fir life. They are animals pure and simple, masquerading under the guise of the vegetable kingdom, and possibly, when all is said and done, deriving benefit in their own way from the likeness. It is to the study and contemplation of these curious sea-flowers that I invite you to-day. The study is not an uninteresting one, if only for the reason that it may reveal facts about living things which do not come under cognisance in every-day life. So let us pick up the sea-fir at our feet, and note the ways of its being and structure, if haply we may only pass an hour of a spring holiday in a fashion that may be at least more profitable than playing with politics, or fighting over matters that belong to the crowd and the market-place alone.

The sea-fir consists of a central stem and branches. So far, it resembles the fir tree itself. It grows, as we have seen, rooted and fixed upon the oyster shell. Therefore in its mode of increase it must also resemble the plant. This is so, for it grows by budding. One part of it throws out the shoots and prolongations which grow into the likeness of the parts already represented, just as one shoot of a tree grows from the parts already in existence, and just as the leaves it produces will, in their turn, resemble the foliage which is proper to the plant. The stem and branches of our sea-fir thus bear the foliage of this strange being, only the foliage in the case of this animal form does not assume the shape of leaves, but of delicate little cups, borne on the branches.

Take this powerful hand-lens and scan the branches, and you will see them studded with the cups or receptacles to which I allude. Now, let us by an exercise of the imagination (in a scientific sense) think of the appearance of the organism when it is teeming with life and vitality. Then, every cup contains a living inmate; so that the branches bear hundreds of little animals, each a duplicate of all its neighbours. It is not difficult to imagine the appearance of the animals. Each has a little mouth, surrounded by tentacles or feelers, which it can protrude in search of food, or retract, as occasion requires. Each mouth leads into a little simple tubular body, and each body in its turn communicates with the hollow branch on which it is borne.

Thus we arrive at the fact that the sea-fir is clearly not one animal but a whole colony, made up of apparently similar individuals or units, each of which is in connection and communication with every other member of the colony by means of the hollow stem and branches. This is the constitution of this curious animal form briefly explained. It is a compound animal, you observe, which has grown by budding into its present shape very much—to return to our original idea—as the tree reproduces its structure and its similar parts by a like process. Through the hollow stem and branches flows the nutritive fluid or blood, as we may term it. Note here how the principle of perfect co-operation exists in the sea-fir. Every little mouth of the colony is seizing food, and every little body digests it; but not for self alone. The digested food is transferred to the stem and branches of the colony, and is made to circulate throughout the entire organism; so that each member of the miniature state draws its own share of nourishment from the common circulating stream it has helped to make.

Anything more perfect than this, in the way of co-operation I mean, cannot be conceived. It is a case of mutual aid, pure and simple. Nothing disturbs the surface of sea-fir life in this respect. Existence flows on smoothly and quietly in the sea depths, between the getting of food and the digesting of it, and the application of the proceeds to the nutrition equally of the whole organism.

But sea-firs do not last "for aye." Vegetative as they are, they must have their evil times like higher forms. Death is constantly working havoc among the members of this colony. The little units droop and die, as do the leaves on a tree. Nevertheless, we see how the same process of budding, which originally brought them into existence, is all-sufficient to repair the losses which death has made. New buds take the place of the old. The gaps are supplied in this way, and the sea-fir thus keeps its individuality and its form among the hosts of its living compeers. It is clear enough, however, that all this budding process will only serve to increase the sum total of the individual sea-fir before us. It will not suffice to produce new firs, any more than the leaves of the tree can be held responsible for giving origin to a new race of trees. In the plant the season of flowering arrives; flowers are the physiological preludes to seeds; and from the seeds spring the new individuals which perpetuate the race in time.

Has our sea-fir, then, any means whereby it can continue its species and throw new individuals into the gaps which death creates when the life of any colony as a whole comes to an end? I reply in the affirmative. Notice on the sea-fir's branches the remains of certain little capsules or cups different from the rest. These are the remains of units of the colony, specialised from the run and ruck of its units for a purpose. That purpose is the reproduction of the race. Within these capsules (which, by the way, are simply ordinary members of the colony set aside and apart for the development of the race) eggs are produced. Whenever you get an egg developed, you begin a new cycle of individual existence. You have done with old things, and your face is set forward to the new order which is destined to arise. And so from these egg-capsules the eggs, properly developed, will in due course be set free. They will undergo the changes proper to their race. They will swim at first freely in the sea. Then they will settle down from their nomadic life, and each will attach itself to some oyster-shell.

Thereupon, each will grow into a single little animal, with its mouth, and tentacles, and body complete. Next, the process of budding will begin. Inheritance declares that the single and simple state is not to be the rule of this embryo's existence. Budding soon gives origin to other units like unto the original, and as they all remain connected, we at last get back to the type of the sea-fir with which we started, and find stem and branches all reproduced for us, and all springing wondrously and exactly from the egg of the parent form.

But there are many variations of this simple process in the allies and neighbours of the sea-fir. For in certain "sea-firs," if so I may call all the tribe, the egg buds do not appear in the guise of simple sacs. On the contrary, they go on growing while attached to the parent colony, and appear before us at last in the guise of small jelly-fishes. Then comes the detachment of these jelly-fish buds. They swim away in the sea, pulsating in their freedom through the yielding waters, utterly distinct from the plant-like colony which gave them birth. For a while they have this free and independent existence, but a sure destiny awaits them. They begin to develop eggs, and when the eggs have been liberated into the sea, the jelly-fish mother dies away.

Next the eggs undergo their own development. Each, after a free life, settles down, develops one animal of the colony, and then through the inevitable process of budding reproduces the fixed and plant-like organism of the "sea-fir" with which we began. This is a more complex cycle than the last. The jelly-fish stage intervenes as a new phase of things; and it is just possible to conceive that jellyfishes, free and distinct, which have no connection with zoophytes at all, may have arrived at their independence and their own personality first of all as the free floating buds of the animal colonies. This may be speculation, but it is a reasonable thought none the less. Otherwise, I think it is difficult to find a reason for the existence of jelly-fishes at all.

That which awaits you and me to-day at the close of this study of the sea-firs, is the lesson of co-operation they teach us. I could show you that in some of these plant-like colonies we may get a wonderful amount of division of labour, when certain units of the colony digest food, and others develop eggs, and others defend it by means of stinging cells. But these facts are only by the way. I myself can see clearly enough that perfect co-operation is a thing you only get in lower life. It is a stranger to the higher existence altogether. Why, is not a difficult matter to discover. Higher life has its aspirations and its ideals, and it works upwards to them. If you start a hundred higher units on the same basis, how long will you find them all trudging with equal pace along life's highway? Not a day. There is no dead-level possible in higher life, as there is in lower life. You must have some units going ahead of the others. Hopes here, ambitions there, failings now, and back-slidings then — all make or mar the chances of getting on in the world on which our eyes and our aspirations are set.

This is where perfect co-operation on the sea-fir basis fails. It gives no room or incentive to better things. It is successful as far as it goes, but then it does not go very far towards the realisation of the fuller life. Human existence is not conducted on such principles, and when we get our different political creeds, or our varying religious or our social factions, these things are only testimonies to the spirit that is in us, and which urges us to make to-morrow a little happier, if we can, than to-day. And this, it seems to me, is the great and good lesson you and I may learn from co-operation in the sea-firs in our simple study this afternoon by the sea.

CHAPTER IV

Germs as Friends

All germs not malevolent—The Greek mice plague and bacteria—Universality of germs—Their use in bread-making and alcoholic fermentation—The part played by germs in the making of butter and cheese—Nature's scavengers—Aids to digestion—Germs as middlemen.

We are usually given to regard the lively bacillus and the sprightly bacterium as our microscopic enemies, attacking our tissues, causing disease, and otherwise maltreating us. This is very natural, because unquestionably germs have much to answer for in this way. It must occur to us, however, that all germs are not justly charged with malevolent intents and properties. It is easy to prove that many germs are not merely very useful to us, but even that disease germs may be enlisted in the service of man.

For example, Professor Loeffler, of Berlin, once upon a time returned from the classic plains of Thessaly, from a mission wherein a special germ successfully brought relief to Greek agriculturists suffering from plagues of field mice. Dr Loeffler was the happy discoverer of a particular germ which causes in mice, and in mice alone, a fatal disease. Cultivating this germ artificially, Dr Loeffler proceeded to Athens with a stock of his material. Experiments at Athens showed that the germ was fatal to mice; and an abundant supply of the germs having been procured, the Professor and the Greek bacteriologists set off to strew, on the Thessaly plains, bread duly doctored with the disease-producing particles. The result was that in a few days the plains were strewn with dead and dying mice, and a ready means of suppressing a very determined enemy of agricultural prosperity was thus placed within the grasp of the Greek farmer. If this plan should ever be successfully carried out within our own gates, we may find an illustration of how even a noxious germ may be pressed sometimes into the service of man.

Possibly our mistake in regarding all germs as our enemies has arisen very naturally out of the common talk about these microscopic organisms as disease-producers. But scientific teaching is first of all very careful to point out that the word "germ" is a wide term embracing countless forms of microscopic organisms (probably plants in nature), and of necessity including many species which have no relation to the particles which lay us low with fever, or terrorise us with tetanus or lockjaw. As a matter of fact, germs exist everywhere. They occur in the purest water and in the purest of air. They teem in the earth and the sea. They are found in milk, and butter, and cheese; they attach themselves to plants, and they haunt our mouths and stomachs all unknown to us.

Beyond this it can be shown that not only are many germs—perhaps, I should say, most germs, having regard to their numbers—harmless, but many are useful to us in respect of the chemical actions and works they perform for us. The germ as a friend is a new phase of its career, and the bacterium as a manufacturer may be equally a novel phase of lower life for us to consider. There is no more familiar example of the germ as a servant of mankind than is found in the case of the various yeasts, which are microscopic plants allied to bacteria, and which are certainly conveyed as germs by the air and in fluids. Common yeast, by its multiplication, will split sugar into alcohol and carbonic acid gas. This action we see in the baking of bread, so that despite "aerated" breads, and so long as we stick to the old-fashioned way of things, it is evident our loaf is, in part, the production of the yeast plants. But the baker is not the only man who relies on germs to do his work.

The wine merchant, in his turn, owes the foundation of his trade to germ action. Certain kinds of yeasts are made to grow in their own particular soil —the juice of the grape. As a rule the vintner takes his chance of finding that into his grape-juice the yeasts will tumble from the air. Here, again, alcohol is produced as in bread fermentation, and again carbonic acid gas flies off. The proper amount of alcohol is left behind in the grape-juice, and thus we get our wine. So also when we manufacture other liquors, our germs come to the front. Our beer is also produced in a kindred fashion. The yeast grows in the malt; alcohol and carbonic acid are formed; then when we bottle our beer we find carbonic acid still inside the vessel, and also the alcohol to which beer owes its stimulating properties.

Apple-juice, fermenting through germ action, gives us cider; so that it is clear one view of temperance advocacy may legitimately be connected with germ action as a source of much misery, if also (according to the "moderates") a source of a certain degree of comfort and joy to mankind. Yeast may be regarded by a scientific teetotaler as in truth a very noxious germ indeed, seeing that without its kith and kin we would probably thirst in vain for anything in the shape of readily-made stimulants.

Allied to alcoholic fermentation, as the work of friendly germs, we, of course, get vinegar-making itself. Wine sours and is turned into vinegar; cider sours also and becomes the latter product. This is vinegar fermentation, depending upon the work of yeasts, or germs, or bacteria other than those which produce alcohol. Alcohol, to become vinegar, requires an additional supply of oxygen. This work seems to be effected by germ growth. It is bacteria which settle down in the cider or the wine, and which form the scum or pellicle known as "mother of vinegar." They are the agents which take in the oxygen, and pass it on to the alcohol, and the result of this plain action is to convert the alcohol into acetic acid, or, in plain language, vinegar. It is much the same in the case of lactic acid. For, as a writer reminds us, germs cultivated in milk sour it, changing its sugar into lactic acid, which has a certain commercial value.

Perhaps, however, the sphere of the dairyman is as fertile as any other in respect of the uses which germ life and germ action subserve. A recent writer has been eloquent regarding the work of bacteria in the domain of the butter-maker and cheese-farmer. Milk, of all fluids, is easily and readily affected by germs. It is an admirable growing ground for them, as we know to our cost when we get scarlet fever, diphtheria, or typhoid from an infected milk supply. The souring of milk, just alluded to, is an illustration of germ action, primarily destructive, no doubt, in so far as the dairyman is concerned, but useful when lactic acid is in question as a product. Cream allowed to ripen for buttermaking purposes acquires its special qualities from the growth and multiplication in it of bacteria. The changes which render it fit for churning are the result of germ growth, and much of the taste and aroma of butter originates from a precisely similar cause. This aroma, it is pointed out, really represents the early phases of the decomposition of the cream—in other words, it is the initial result of the process of pulling the cream to pieces in a chemical sense.

Beyond this initial stage the process would become offensive. Cream goes to the bad like other things, and the secret of successful churning is really the seizing of the cream at the stage in which its contained germs have gone a certain length only in their work of alteration and change. With cheese-making it is the same. Germs play an important part in the manufacture of that product, for the ripening of cheese, like the ripening of cream, is an action due to the multiplication of bacteria. The casein of the cheese is being altered under the influence of the germ growth, and the particular taste and aroma of a cheese depend upon the stage at which the germ action ceases to be actively represented in the history of the food.

But a more intimate acquaintance with cheese-making reveals the fact that the varieties of cheese which are found in the market, each characterised by its own peculiar flavour, seem to owe their peculiarities to the special germs which infest and act upon them. It is described how, in the making of Edam cheese, a little decomposed milk—that is, milk which has undergone change at the hands of germs—is added to that whereof the cheese is made. The bacteria in the added milk give to the Edam cheese its special flavour.

The Limburger cheese and other varieties, each made under special conditions of its own, illustrate the same specific work of germs in imparting taste to our foods. What the cheesemaker wants to-day is more special knowledge or power of getting the bacteria he requires to set to work on his own terms. The brewer has cultivated his yeasts, and is able, as has been pointed out, to secure very even and stable results in his operations; but the cheesemaker has not yet attained to the felicity of the brewer's acquaintance with, and usage of, microbes. When such knowledge does come there can be no question of the effect it will have upon cheesemaking at large; and there are indications that the science of cheese manufacture is already prepared to avail itself of the latest investigations into the history of bacterial life.

There is yet another aspect of germ life and growth which will bear mention when viewing these microscopic particles from their amicable side. That they act as Nature's scavengers and as Nature's sanitary police cannot be doubted. Their *rôle* in removing waste and deleterious matter from the world, by decomposing it and converting it into other and less hurtful material, is really an all-important one. Much of the purity of air, earth, and soil is due to bacterial action. They break down the dead tissues of animals and plants, and thus favour the speedy removal of decaying matter; and this is no light or trivial task when regarded as part and parcel of the economy of nature.

Physiologists will even go the length of telling us that our own processes of digestion are aided and influenced in no unimportant manner by the germs which find an apparently natural habitat in our digestive system. If, therefore, they afflict and affect us injuriously in many ways, none the less do bacteria play the part of benefactors both without and within the human territory. Their assistance to higher life is not limited, however, to the human domain. Many plants owe a very important power they possess in the way of food-assimilation to germ aid. Most readers are aware that plants demand a certain amount of nitrogen in their food, seeing that without nitrogen it is impossible to form living matter, or, in other language, protoplasm. This particular element in plant-food is usually obtained from the soil; but certain considerations seem to make it plain that another source of this element is drawn upon, by some plants at least, as a food supply. In the form of ammonia or of nitric acid, plants as a rule seem to obtain nitrogen, and this notwithstanding that in the air around us is a plentiful store of that element.

For ordinary air consists, roughly speaking, of nearly four parts of nitrogen to one of oxygen—the real proportion is about 21 of the oxygen to 79 of nitrogen, in 100 parts of air by weight. Now, it is evident that the atmosphere is a big storehouse of nitrogen, and yet plants seem to be unable to avail themselves of it. I say "seem," because we cannot dogmatise about plants at large in this respect, though what we do know about the abilities of some plants to seize the air nitrogen for food suggests possibilities of infinite kind in this direction as regards many of their neighbours.

The family of leguminous plants, of which peas, beans, vetches, and the like are familiar members, is able, by the aid of germs, to assimilate the nitrogen of the atmosphere. The story of the friendly assistance rendered by lower life to life of a higher grade is extremely interesting. It would seem that when, say, peas are planted in a particular kind of soil wherein bacteria are found, these germs gain access to the rootlets of the plants, and there increase and multiply. The result of this visitation of the roots by germs is to cause the appearance, on the roots, of small nodules or swellings, to which botanists have given the name of "root-tubercles."

Between these tubercles, and the power of the plants to take in aërial nitrogen, there is so close a relationship that it is impossible to mistake the nature of their functions. In the absence of the tubercles the plants languish and die if the soil itself contains no nitrogen. If the tubercles are present in that same soil, the plants flourish, and as their only source of nitrogen food must be the air, by a process of exclusion we discover that the germ-growths are the means by which this element is obtained and utilized from the atmosphere direct.

Probably the germs play the part of middlemen between the plant and the air. Farmers know that an exhausted soil recovers itself in some mysterious way if clover or beans are grown upon it, both being leguminous plants. Why should such growth enrich the soil when the roots of the clover have been ploughed into it? Clearly because the stored-up nitrogen which the clover has got from the air, independently of the soil, is put into the earth in the ploughing, and the germs of the soil attacking the nitrogen decompose it, liberate it as nitrates into the earth, where it becomes useful for the feeding of the next crop grown therein.

CHAPTER V

A Little Sermon on Noise

Music and noise — Mildness and flutes — German bands — A League for the Suppression of Noises—The sphere of its operations—A night's experience—A Chinese punishment.

PHILOSOPHERS tell me that the real difference between a musical sound and a noise consists in the difference of the intervals which separate the waves or vibrations of the sound. This is what Professor MacBore informed me the other evening in a moment of scientific confidence at the Symposium Club. MacBore is popularly believed to be an authority on sound, so I take his statement freely and frankly, and without the proverbial pinch of salt wherewith one is apt to season the sayings of lesser minds.

I live next door to MacBore, who, I may add, has given several "hostages to fortune" in the shape of sons and daughters. I do not know the exact numerical strength of the MacBore population, but he may well be "blessed," for he has a whole quiverful of them. Now the members of the MacBore family possess a *penchant* for music. They play a variety of instruments. The girls play the piano, and one or two in addition play the violin. Young MacBore plays the 'cello. It is currently reported that the Professor himself has an occasional wrestle with the double bass, and it is generally believed that a youthful member of the family is taking lessons on the drum.

The partition walls between my house and the MacBore domicile are thin, very thin. There is no evidence that any deadening or deafening process ever entered into the builder's head when he constructed the terrace in which I have the privilege of residing. Possibly the deadening process was limited to the builder's own head, but of that Providence alone, and not I, must be the judge. Anyhow, when the MacBore quartette, quintette, sextett, or septett, begins its work of an evening, peace flies horrified from my humble dwelling. I am not a fidgety person, and I hope I am a law-abiding citizen, but the quiet that one enjoys after a hard day's work is not mine, and the MacBore concerts, like Tennyson's brook, "go on for ever."

In moments of mental despair, induced by three hours' muffled auditory of a symphony which seems too much for the MacBore talent, I catch myself wishing for a holocaust of the MacBore musical instruments. But as the Professor tells me he is "well insured," I presume his policy covers piano, Cremonas, double-bass, and drum alike, so that an easy replacement would follow any attempt at cremation one might plot or carry to a successful issue. Nor is this all. Two youthful clergymen live on the other side of me. They have both joined the famous Church Society, and are going in for the practice of Gregorian music, played with one finger on a harmonium hired by the month.

One also plays the flute. I notice all mild young men take as naturally to that instrument as ducks take to water. Why this is so, I leave for philosophers to determine, only I know that nobody (save a man who makes his living by it) with any self-respect should play the flute. "'Tis a pity that playing the flute should make a man look such a scarecrow," observes one of Thomas Hardy's rustics in "Far from the Madding Crowd." This is true wisdom. For the hideous grimaces involved in such a performance are many and varied, and any doubts regarding man's evolution from an anthropoid ape may be speedily solved by watching the eccentricities of physiognomy which are a necessary part of the flautist's execution. I know that to hear an amateur flute-player always makes me shut my eyes out of respect for my race. If I don't shut my eyes, I get (shall I confess it?) a severe pain in my stomach.

This statement will serve to introduce my few (but interested) remarks on Noise as a Social Factor. Macbore may be quite right about wave lengths of sound making the difference betwixt noise and music, or about the irregularity of the noise and the beautiful regularity of the vibrations in the music. All I venture to remark is, that for all practical purposes his music is a Noise (with a capital N, please) to me, and nothing more. It may be that the walls interfere with the full development of the music, but that clearly is no affair of mine. My peace is destroyed; the harmony of life is gone. I cannot read, I cannot even sleep comfortably, because of the Noise next door.

As for the Gregorian music and the flute on the other side, I seriously think I should prefer a German band, and *that*, I need hardly say, is about the last thing for which any sane person can express any preference whatever. At the least, or worst, you only get a trombone solo (outside) when the cornet and flageolet are ringing the bells and collecting the coppers. But the flute and the harmonium together make up a combination which can only exist in some "Inferno" of lost souls given to chronic wailing, or which may perchance be represented in the neighbourhood of a pigstye where the butcher is engaged in the exercise of his gruesome art.

By the way, talking of German bands, I have always been given to understand, on the authority of persons of culture, that Germany is a musical nation. How that opinion can be reconciled with the exhibitions one hears in the streets is a difficult problem to solve. I have heard of two enthusiastic musical amateurs, who, being left resourceless in a country inn on a wet day, practised the divine art with a Jew's harp and a comb. Personally, I should prefer the harp and the comb to the excruciating performances of the common or garden German band. The former performance may be amusing—probably it is very amusing to the bystanders—but as for the Teutonic contingent playing "Annie Laurie" in four different keys all at once—well, may I be permitted again to suggest forcibly (though I trust, politely) that the hearing of such murderous melody always gives me that gastric pain to which I have already (and delicately) alluded.

Music performed under circumstances which I trust I have made sufficiently clear is nothing more or less than Noise. It does not soothe the savage breast (or beast); on the contrary, it irritates, vexes, annoys, and initiates thoughts of a suicidal nature. I propose, therefore, that all sufferers from Noise of this and of every other description should unite to form a League. Everything nowadays to be successful must take the form of a League. We see what Irish patriotism has done in this way, and I am fast getting to the idea that to put down Noise and to make life tolerable, my League must adopt some (I do not say all) of the tactics of the Hibernian association. I would propose that the League, when formed, should send to MacBore, for instance, a pen-and-ink sketch of a coffin and cross-bones, with the intimation that if he does not confine his Noise within reasonable hours and limits, he will be sent to practise music in another sphere. This, only by way of threat, of course.

Then our League might make war on German Bands. Our emissaries might fill the trombone with water, or the bassoon with beer, to which latter fluid there might be no objection, it is true, on the part of the performer. A little "moonlighting" (MacBore's tablemaid might be enrolled as a member of the League) might be performed by way of "damping" the piano, if all other measures failed. This, of course, would be our *ultimatum*, but the notion that an Unseen Hand was at work to limit the performances of Noise everywhere, would soon produce its effects. MacBore would have to "hire a hall," and leave the peace and sanctity of his own and his neighbours' houses undisturbed.

As for the flute and harmonium, our League could easily work on the feelings of the juvenile ecclesiastics by assuring them that a continuance of the disturbance would be positively fatal to either of them getting a kirk. We would permit noise in the pulpit freely and ungrudgingly, but we would have no "tinkling cymbals" at home.

This is my project. Of course there will be objectors. What great and good scheme for the betterment of society has ever existed which has not had its detractors? Why, even the mild Socialist who wants your coat (because he has not got one of his own) is regarded by many as an unutterable idiot and worse. So I am quite prepared for criticism, and in the language of Macbeth (I think he was the gentleman who made the remark in question) I say "Lay on!" I am, at least, sure of the sympathy of many elderly maiden ladies, of a few widows (of mature age), of club gentlemen over fifty, and of all the scientists. These will do to go on with, and more will join us, I doubt not, for a peaceful life, free from Noise, is just what we all desire and what few of us attain.

Naturally, there are many fields of work and labour for the cultivation of the League for the Suppression of Noise. We shall interview Town Councils on the subject of wood pavement, for instance, and point out the saving to nerves and brain when the rattle and roar of traffic is limited. We shall plead with carriage proprietors to give us indiarubber tyres, which will cause us to float noiselessly about in our British gondolas, otherwise and vulgarly known as cabs. We shall ask Railway directors and others of that class to introduce the mellow "hoot" in place of the drum-splitting screech with which their locomotives now herald their intentions.

Then we shall be down on church bells, that in all their brazen "clang and clash and roar" disturb the stillness of the Sunday. The clergy will be told that bells are the survival of a barbarous period, when they were believed to be of great utility in keeping away the devil and all his works. Respectable people know perfectly well when their church "goes in," and they don't need to be belled into service; while the wretched tinkling bell of certain chapels, which goes at all hours and seasons, rousing you out of your morning nap, and making all other hours hideous, will, it is to be hoped, be reformed off the face of the earth altogether.

Of course the misguided and selfish animal who keeps fowls in his backyard, and always boasts of a rooster who is given to early rising, and to letting all the world know he is up, will be severely dealt with. Metaphorically, we will have our knife in him; I should like to have my knife in the rooster (boiled, for preference) but for the fact that he is certain to be old, and therefore not to be dissected by anything short of a hammer and chisel, or perhaps a saw. But the person who keeps what some miserable wretch of a poet has called "bright Chanticleer that marks the dawn" on his premises in the city, is an unmitigated—well, I won't say what, but I will *think* it all the same.

And it is the same with this person's dog. That dog is always a stout, well-favoured animal as to lungs. His larynx, or organ of voice, is made of cast-iron, and when he begins to bark at 5 A.M., roused from slumber (if he ever sleeps) by the fairy-like tread of the policeman, he goes at it till at least 8, when he gets his breakfast, and on the strength of that refection throws in another half-hour's barking by way of grace after meat. The Eskimo dogs are said never to bark. What a treasure an Eskimo dog must be. (*Mem.*—To invite the League to consider the advisability of importing a cargo of Eskimo dogs to inaugurate the beginning of the voiceless canine as a feature of our social life.)

The other night it was my fate to sojourn for a night in the Grand Central Caravanserai, which, as everybody knows, is our palatial hotel, where (as in a convict prison) you are only known by a number. Everything was up to date. The food was excellent, the bed comfortable, the smoke-room big and airy, and I enjoyed my stay. But when the night began, my sorrows increased and multiplied exceedingly. I retired to rest at 11 P.M., which, it must be admitted, is a reasonable hour whereat to seek repose.

By 11.15 I was in bed. Like Lady Macbeth, I went to bed, and, like that venerable lady, I was not permitted to sleep. First there came a gentleman, who, after slamming his door loudly (he was in the next room), began to argue with himself on some point of law. Then he kicked his boots from one end of the room to the other, presumably typifying what he intended to do to his adversary. Then he opened his door, flung his boots out so as to hit the door on the opposite side of the passage, and then (of course) slammed the door again. He got to sleep after this and snored all night. (*Mem.*—To invite a conference of medical men to the League to hear suggestions how to prevent snoring.)

Then I began to doze off. In ten minutes afterwards up comes my other neighbour. He couldn't get his key into the keyhole. He used some remarkably strong and eloquent language about keys at large. Finally he got the door open, and (of course) slammed it after him. This performance was repeated by other arrivals at intervals up to 1.30. Then thought I, "Thank heaven! peace at last!" But I had not reckoned with a fancy ball. At 4 A.M. up they came by the half-dozen, laughing and chattering, shouting the whole length of the passage with "Oh! I say Charlie!" and "Oh! I want to tell Jimmy!" and "Oh! that reminds me!"—and I lay and groaned.

At about 5 A.M. I dosed off again for the twentieth time. At 6 A.M. up comes the boots. He can't put the boots down quietly. Oh, dear no! He slams them down, and whistles "Maggie Murphy's Home' all the while in a style which Mrs Shaw herself might have envied. At seven A.M., up come the maids. Some sleepers have to be awakened at that hour, and the girl devoted to this duty hammers on the doors in a fashion I had previously imagined was only practised by policemen.

Then the passage is swept, and the blithe maiden sings (this time it is "The Man who Broke the Bank at Monte Carlo") as she sweeps. That girl should devote her leisure time to preparing for the music hall stage. At seven-thirty, there is noise all round. It is impossible to get even forty winks. I rise from bed tired and unrefreshed, ill-tempered, and not in the least like the man who went to bed at eleven last night.

A Little Sermon on Noise

There is a Chinese punishment which consists in letting a criminal just drop off to sleep, and then awaking him. I am told after a week of this exciting existence the criminal prays to be killed right off. I have personally realised somewhat of the feelings of that Chinese unfortunate. I know what it is to get five minutes at a time, and to have some sleep on the principle of the stories in the penny weeklies—in short instalments, "to be continued in our next"—and all this arises, with other ills beside, because in this world people will not give a thought to the prevention of Noise.

CHAPTER VI

The Modern Elixir of Life

Chemical "Analysis" and "Synthesis" — The imitation of natural compounds — Wöhler's discovery — The barrier between the living and non-living broken down—Modern successes along this line — Vital substances imitated — Where science halts.

THAT phase of life in which we see the living being as a chemist, building up the compounds which distinguish it, and for which, perchance, man values it, has of late years become of singular interest to science. When chemistry began to improve its methods, and to investigate the composition of animals and plants, the first idea which was present to the minds of scientists was the hopelessness of any attempt to build up in their laboratories imitations of the substances peculiar to living things. "Analysis" is the work of chemically pulling a thing to pieces, and of resolving it into the elements of which it is composed. "Synthesis," on the other hand, is the making of substances, artificially, as it were, by bringing together and building up the elements found in them.

It was this synthesis of living compounds, this building up of the substances found in animals and plants, and this imitation in the laboratory of the work of Dame Nature outside it, that at first appeared a very vain and hopeless search to chemists. There is no stranger story to be told than that which teaches us how, with the lapse of years, the search after this ideal has been successfully realised. Going back to somewhere about 1828, we find the beginning of this curious chemical work of imitating nature in a discovery of Wöhler, a Continental scientist.

Urea is a substance which represents in part the living waste of the animal body. It is typically excreted or separated from the blood by the action of the kidneys, and it is in its way a most important principle as regards its waste-character, because very serious results follow from its retention within the system. In itself, urea represents the waste of the nitrogenous tissues of the animal frame, and as these tissues are the really vital and living parts of the organism, we see in the function for getting rid of urea one of the most essential parts of the work of excretion.

Here, then, is a product which in itself may be taken as a fair example of the results of living action, for the excretion and separation of urea by the kidneys of animals is a highly complex business, involving the exercise of strictly vital functions. When the chemist is asked to specify the composition of urea, he tells us that it consists of four elements, carbon, hydrogen, oxygen, and nitrogen, combined in certain proportions, these elements being precisely those which are found in living matter itself. Now, Wöhler experimenting on the possibility of building up this complex compound artificially, found that success awaited his efforts. For by reacting with ammonia on cyanic acid he produced urea, and for the first time, in 1828, broke down the barrier which was supposed to stand between compounds made by the living body and those of the non-living world.

The importance of this discovery is not difficult to realise. It led chemists to inquire whether or not the distinctions which had very naturally been set up between things living and things non-living were quite so real and so formidable as at first sight had been supposed. From the year 1828, chemical progress had made very rapid strides in the direction indicated by Wöhler's discovery. For instance, the alcohols were long regarded as bodies only to be produced in nature's own processes. The fermentation of sugar through the action of living yeast plants is a work in which these plants split the sugar into carbonic acid gas, which is given off, and alcohol, which remains behind. This is what happens when yeast is used in the baking of bread. The production of alcohol, thus regarded, is truly a result of living action, and not of any purely chemical and physical operation.

Yet chemists are now able to imitate nature in the closest fashion, for alcohol can now be made or built up by them in more ways than one. Thus it can be made by the action of sulphuric acid (or vitriol) on a product called ethylene; and Wurtz showed that when aldehyde and hydrogen were used in a particular way, alcohol was the product which resulted. It is of extreme interest to find chemists telling us that when plants make alcohol they operate in the way in which Wurtz himself worked to attain that end.

What the chemist is able to do in his laboratory, that the plants do in their living cells. Art, for once, has successfully imitated nature, and the chemist is therefore beginning to ask himself seriously enough whether, with evidence of such successes before him, he may not be more hopeful than before of being able to approach much nearer to the very arcanum of life itself. This, as we shall see, is the crucial point of the whole position. It may be a hopeless task this of getting absolutely level with life, and of being able to manufacture living tissue itself, but at least chemistry has the right to aspire. The art of manufacturing living stuff may be a realisable idea, even if the power of endowing that material with vitality may be regarded as a thing beyond the furthest reach and hope of scientific aspiration.

It is not alone in one domain or phase of vegetable chemistry that science is able to keep abreast of nature's synthetical labours. There exist in many plants what are called active principles or alkaloids, in which reside the special chemical features of the plant-chemistry. Theine is the alkaloid of tea, as caffein is the principle of coffee, and theobromine of cocoa; while digitaline is the principle of foxglove, and aconitine and many deadly poisons represent the alkaloids obtained as the essential principles of other plants. These substances are admittedly of complex character. What Friar Laurence in "Romeo and Juliet" has to say about the "mickle grace" that lies enthroned "in herbs and their true properties," applies specially to the essential principles of plants. On them all the force of the plant chemistry has been expended in the process of production. Yet we find the chemist of to-day able in a very marvellous fashion even to overtake nature in this complicated process of manufacture.

An active plant principle called "cicutine" is characteristic of the water-hemlock; and a substance, only slightly differing from cicutine, but possessing all its poisonous properties, has been artificially built up by chemistry through a special and ingenious process. Up to this stage the conservative party in chemistry, as M. Armand Sabatier has pointed out, frankly acknowledged that very important territory had been wrested by chemical science from the sole and uncontested possession of life—as itself a chemical worker. Yet beyond this stage lay a whole host of substances, more nearly connected with vitality, and such as seemed hopeless of attack. It was pointed out that what vital things chemists were able to make and to imitate were mostly "waste" things, such as urea and alcohol and formic acid (this last found in the nettle-sting and the bites of ants), and that the higher living substances, like protoplasm itself, and other forms of albumen (and likewise such natural products as sugars) were beyond the art of the chemist in respect of their imitation.

This challenge is not of very remote date. The art which succeeded with urea and alcohol, it was held, could not enter into the very heart of the living cell and imitate the work of vitality in building up matters more closely associated with life. "The work of life cannot be counterfeited"—this was the expression of a scientist writing in 1886. You may imitate artificially nature's process of refuse-making, said the conservatives in chemistry; you cannot follow her deeper into the living tissues where life is at work in its own mysterious and insoluble ways.

It seems that the substances most directly associated with life and vital chemistry possess a power of turning the plane of polarised light to the right or left, and this property, it was held, could never be found in any body artificially prepared. By way of showing how unsafe it is to dogmatise regarding scientific progress, it may be added that the artificial building-up of sugars is an actual accomplishment of the laboratory; and not only so, but the behaviour of these artificial sugars to polarised light agrees with that exhibited by the natural life-made substances. Nor apparently has chemistry stopped with the synthesis of sugars.

Very recently, indeed, Schutzenberger has shown the world how near an approach can be made to the artificial manufacture of some of those compounds that of all others have hitherto been regarded as specially vital in their nature. It is known as a familiar fact of philosophy that when any of the nitrogenous substances—such as albumen of egg and meat, the casein of milk, and the like—are taken into the stomach, the gastric juice of that organ, acting upon these foods converts them into what are called "peptones." These peptones readily pass through the stomach walls and gain access to the blood. Schutzenberger has succeeded in building up a peptone, or at least a substance which shows all the reactions of peptones, and which must therefore be taken to indicate the plain possibility of chemical science being able to form these matters and the more representative albumens in the laboratory.

Of course, there lies beyond even this great scientific feat the question of life itself. What is known is that the chemist apparently can now imitate in his workshop the material substances which are associated with life wherever we find it. To expect that he can endow such material with vitality, and even with the vitality of the lowest living animal or plant, is, of course, an inconceivable idea as things are. It appears a fair enough assertion, even in the face of what the wondrous powers of chemistry have lately accomplished, to state the futility of the notion that vitality itself could be produced as an affair of chemical combination.

That which science has really done in this respect is to imitate successfully the work of nature. But, just as it requires the living chemist in his laboratory to effect this building up of imitations of living substances, so it seems we require the little living chemist in our plant cell to effect such building-up in a natural fashion. That which strikes us about life is that apparently it is always derived from preceding life; always handed on; always transmitted—never spontaneously originating, never springing out of nothing suddenly into existence. The microscopic yeast plant, which splits the sugar into carbonic acid gas and alcohol, is the progeny of a parent yeast plant, as in turn it will become itself the parent of offspring. The lowest animalcule that finds a world in a water-drop, is the direct descendant of a pre-existent parent animalcule.

It is the same with every other living thing. The world of to-day is peopled by the descendants of its yesterdays, as its to-morrows will see the offspring of its living tenants of to-day. Life is always transmitted, never spontaneously created—this, at least, is what both experience and scientific research demonstrate to our waiting eyes. And if, hearing so much, we eventually turn back to the beginning, and ask, "Whence then, came the first life? and how was it related to the ordinary chemical and physical forces around it?" science can only refer us to the possibility that life began in very humble guise, that it possibly began in the shape of the living specks which are still with us to-day, and that, out of these feeble beginnings the potentialities of creation have evolved through the ages all the wondrous living variations the world exhibits to-day.

If so much be true, is it not possible to see a good reason, philosophically regarded, why it may never lie within the chemist's power to create even the humblest and lowest of living things? Is it, plainly speaking, because the conditions under which life first appeared on the earth no longer exist. That which was easy at creation's start is no longer possible. If the non-living became elevated into that which was living when the world was young, it seems fairly evident that no such process exists, or in truth is required, to-day. But if so much be matter of fair speculation, one can see why chemistry must draw the rein at the territory wherein life reigns supreme. The material of vitality it may manufacture; life itself, not being a material thing, but some subtle force or other, really lies outside of the chemist's province altogether.

CHAPTER VII

Day Dreams, and Others

A reverie described — Absent-mindedness — Mental condition during abstraction — Hypnotism in a nutshell — A case of lapsed mindwork — The physical basis of transcendentalism—The ludicrous side of abstraction.

THE lunch table at which to-day I have been most hospitably entertained has not yet been cleared, and my host and myself have been dwelling over the long-drawn-out flavour of as prime a Havana as ever grew in the Antillean groves. The stillness of the day has assisted the fragrant weed to lull us into a repose in which everything—business, cares, worries, joys, and sorrows, and all the activities of life itself — seems distant and afar off.

Have you ever experienced this brief putting of things into the background of existence? I suppose every man in his season of great content—the season all too short for most of us, and for some of us never represented at all—has felt that time and space were for a while annihilated. You sit, as I do, on this warm afternoon of May and dream. You are in another world for the nonce. The present hour has gone, and the blue smoke from your cigar is the incense wherewith the great magicians, Imagination and Memory, invoke their familiar spirits. The blue wreaths twine and coil in the air, amid the silence that is unbroken, save by the soft coo of the doves in the arbour and the twittering of the birds in the trees. Back goes memory to happy times. The old familiar hand-clasp is felt, the words of love and trust are spoken again, the sun shines brightly, and life is in its heyday; and then, alas! you wake out of your reverie to find "it was only a dream," and that only in the dim vistas of your recollection had you beheld the faces you will see no more.

This is what a reverie does even for the practical man, aided by the somnolent effects of a bounteous lunch and a good cigar. To-day my host and I smoke on in silence. He is back in Australia amid his sheep and his shepherds; his thoughts run on droughts and deaths, and he is reviewing the struggles which led him on to fortune and prosperity. The whole drama of his life is being played before him, with himself as sole spectator, and I am in like mood to him. But the coffee comes, and neat-handed Phyllis wakes us out of our dreams. We pine for the "might have been" of life, but like sensible men recognise that "to-day alone is ours," and that "the mill will never grind with the water that is past."

There is much more in this matter of reverie, day-dreaming, or abstraction—call it what you will—than at first sight meets the eye. It is this power of abstracting oneself from the everyday world around that makes up three-fourths of the life that is unconscious and automatic in its character. There are all degrees of abstraction, from the absent-mindedness of common life to the deeper stage of things which constitutes reverie itself. An absent-minded man may, and very likely does, perform many foolish actions; his faults being those of omission rather than of commission. He may return answers the very opposite of those which common sense dictates to the questions of others, but as a rule he is easily aroused from his "wool-gathering" fit, and returns at once to the enjoyment of his ordinary intellectuality.

It is a deeper and different thing with the reverie. There you are really removed mentally from the world and its ways, and that in a very complete fashion. Seated in your chair, what happens to you? A person enters and addresses to you a remark, but you hear him not. It is not that your ears have been closed against the access of sounds. On the contrary, they are open as usual, but the sound waves apparently go no further than the unconscious sub-office of your brain which parcels and assorts them out, and they awaken thus no conscious response in your intellectual centres. You hear as though you heard not; and this last declaration is really true; for you do not "hear" in the only sense of the word which is at all logical, that in which you know what is said to you.

Now, deepen this fit of abstraction somewhat, and you get to the sleep-stage of things. Still continuing your abstraction, let your dream waken up your muscles, and you arrive at the sleep-walking stage. Again, suppose that the fit of absent-mindedness has been induced from without by some person tiring out your eyes or your ears or otherwise affecting your thinking centres, and you at once come to the real explanation of hypnotism. This is only induced or artificial absent-mindedness when all is said and done. Somebody tells you to do something, and you are too lazy (mentally regarded) or too feeble (from a brain point of view) to resist his suggestion, and so you do whatever he directs.

This is mesmerism in a nutshell. You get your higher brain-centres switched off, and you let your lower centres come to the front of things—that is all. You can suggest a dream to some sleepers by whispering in their ears, and hypnotism is a kind of dream-state in which such suggestions are easily carried out. But you see how the whole process has the day-dream as its foundation. It is this faculty of abstracting and withdrawing ourselves from the present world, and all that in it is, that begins and ends many a queer way and work of our brain.

But there are conditions of mind of which the reverie, or something nearly akin to it, may be regarded as the starting point, and which lead us farther afield into the ways and works of brain-action than even hypnotism itself. There are periods of forgetfulness of outside things occurring in the lives of many men such as may well give rise not only to wonder, but to veritable alarm. It is as if, writing the record of one's doings on a slate, somebody wiped out the middle part of the writing, and left only the beginning and the end of it for our subsequent comprehension.

Here is one of the last recorded cases of this lapse of mind-work bearing a close analogy to the reverie I have been indulging in after lunch to-day. A clergyman is in apparently good health; he is an earnest man, active in parochial duties, and busying himself perpetually over the affairs of his cure. He is, moreover, a teetotaler, and sleeps and eats well. So far, the man's personal history seems, on the face of it, to be excellently ordered. But he suffers from a curious sensation when he ascends the pulpit on Sunday and begins his discourse. The thought flashes across him as he speaks, that he has not left the pulpit since the previous Sunday. He has lost consciousness of the work and events of the whole of the week which has intervened since he last addressed his hearers. This interferes, as might be expected, with the flow of his oratory. He reads his sermon mechanically, bethinking himself all the time of the strange feeling of the lapse of memory of past events.

Now, here there is illustrated a case of abstraction which in some ways is akin to the reverie. It is as if the pulpit surroundings induced a condition of absolute forgetfulness of everything else. They apparently revived the idea of the previous Sunday's work, to the exclusion of every other and intermediate memory. This is a result, no doubt, of brain weariness, cured in the case I quote by the rest of a holiday. There was an uneven balancing of the brain, and certain centres acting out of harmony come to the front, for the time being obliterating all recollections save those suggested by the pulpit appearance.

The physician who chronicles the case reminds us that the same abstraction may follow from causes other than those dependent on brain-worry or brain-fatigue. William Blake, the poet, said that "the world of imagination is the world of eternity," and, writing to a friend regarding a poem he had just completed, he remarked that "the time it has taken in writing was thus rendered non-existent." Blake's idea, mystic that he was, held that the poem had been dictated to him by some spiritual power, of which no man knew aught. Thus, a man may in his emphasised abstraction pass into the seventh heaven of ecstasy, poetic or otherwise, just as in my own humble day-dream I hear a voice and feel the touch of a hand which for me, perhaps, exists no more on this side of the great bourne.

I have heard it said of Milton, as of Blake, that his mind during the composition of "Paradise Lost" was in the condition of a "sublime waking dream." If I mistake not, it is Macnish who employs this figure. To realise something of the sublime, I suppose it is necessary to forget earthly things and commonplace surroundings; and in this sense there may exist neither a great poet nor any other high priest of humanity who does not possess his hours of reverie, wherein what is best and highest in him takes root and shape for future use. But the true balance of mind is hardly to be found in abstractions and reveries carried out and onwards to become chronic and lasting things. A little imagination is the salt of life; too much of it embitters existence, and produces the unpractical day-dreamers, who are always hoping against hope, always scheming big things, always building their castles in Spain, always projecting grand ideas which never come to pass at all.

This is the reverse side of the reverie, and it is a side that leads onwards to not a few of the follies and delusions which environ and encompass the lives of men. In ordinary life abstraction has its ludicrous side and its inconvenient aspect. What are we to say of Newton, who on one occasion, his head full of gravitation, no doubt, used a lady's finger as a tobacco stopper? Or of Archimedes, who, with a soldier about to kill him at the siege of Syracuse, merely observed, "Noli turbare circulos meos." There is a fairly authentic record of a worthy man who proceeded upstairs to dress for dinner absorbed in a train of thought. His wife, wondering at his long absence, proceeded to his bed-room and found him in bed fast asleep. Automaton-like, the act of removing his watch and valuables from his ordinary clothes had directed his lower brain-centres in the direction of undressing as a preparatory move for bed.

There is also another tale of a certain Budœus, who was so deeply engaged on a commentary that he forgot his wedding-day. History does not record what the lady said (or did) on this occasion. Perchance some very forcible reminders in after-life cured the "great Budœus" of his learned abstraction. Dominie Sampson is not at all a bad illustration of a type of the "abstracted" man, and Mr Cargill, in "St Ronan's Well," is perhaps the most typical figure ever drawn of the absent-minded individual. After all, we really exist, mentally, as well as actually, between the busy, everyday practical world on the one side, and the world of imagination and memory on the other.

Happy he who can keep the balance even, and who, while ready for the work-a-day life and its affairs, can also withdraw now and then into "the land of happy thoughts and memories sweet." There are many worse things in life than a day-dream; and now that mine has come to an end, let us sally forth into the sunlight and enjoy the living, breathing day.

VI June 1, 1921

CHAPTER IX

The Pike in the Pool

The mill and its surroundings—The joys of the angler—About the pike—The age of fishes—Some ancient pikes—Old Izaak and his frog.

BEYOND the mill which nestles on a by-current of Father Thames, and embowered amid the trees and brushwood of the plantation's edge, lies one of the happy hunting-grounds of lovers of living nature who dwell in those parts. Even when the mill is busy, and the flour dust adds a new layer to the venerable woodwork of the mill-house, you may be more than quiet in the shadow of the willows by the pond. Where its waters come from no man knoweth, but its springs are evidently numerous and perennial. In the hottest days of summer, the water-level remains the same. There is no decrease in the extent of the pond, and it presents in the warm and lazy hours of the year's ripening-time as cosy a nook as you may find in all the Berkshire land around you, or in all the Oxford territory which abuts on your host's possessions.

You are not too far away from the Isis itself to miss the merry cries of boating parties, or the screech of the steam launches that perpetually rush hither and thither through the reaches of the river. If you wish for objects for your microscope you may find them by the hundred in the waters of the pond. Crawling amœbas and others of that ilk, and rotifers, and insect larvæ, not to mention diatoms and lower plant life at large, are all to be met with in the miniature lake before us. Away up under the trees, where the pond merges into a deeper pool, there are pike to be enticed out of its depths, and perch are common objects in its waters. Around the margin of the pond, if your tastes are botanical, you will find a rich harvest of plant-life, from water crowfoots and ragged robin to the water-parsnips, the sweet sedge and the purple comfrey itself.

Your host has set a seat close by the edge of the pond within a natural bower of overhanging branches, and here, safe from the heat and toil of the life that is, you may "read, mark, learn, and inwardly digest" either the stories of men written in books, or the history of the nature that responds to the heart that loves her—if Wordsworth is to be believed. Once upon a time I knew a man who held that there was the greatest fascination possible in the sight of water. An extraordinary statement truly, but one which he supported with much ingenuity and exercise of specious argument. The sea in all its glory, in storm or in calm, attracted him, as it has attracted many a poet before his time, and as it will attract many a singer when we are dead and gone. The river, ever hurrying on to the sea, spoke to him in another key, telling of life's ever-changing moods. The big lake, calm and majestic in its repose, gave yet another turn to his mind, and the quiet pond in its stillness figured forth the life apart from crowds, and suggested the silence of the cloister itself. A quaint fancy this, but one which sprang from a mind full of sympathy with the beautiful in its surroundings. My friend was not the first man who felt that water was a potent factor in the beauty of nature, and he certainly will not be the last to enjoy and appreciate its influences on the human mind.

To-day the talk has turned largely on fishes and fishing, on modes of capturing the finny tribes, on baits and flies, on close seasons, and like topics. Once started, one knows how difficult it is to get an enthusiastic disciple of Izaak Walton to change his pet subject for any other. The story of the inevitable big pike that haunts every angler's reach applies to our pond, for a veritable Nestor of the species is known to live in the pool beyond, and once or twice I have seen him myself lazily resting, as is the custom of his class, as motionless as a stone fish in mid-water, so to speak, not moving so much as a fin for hours together. This pike is a philosopher, as all ancient pikes are. He is the kind of fish that winks familiarly to the angler who tries to lure him to gulp down a nice big well-baited hook. All kinds of bait come alike to him, though he is dainty enough in his feeding, and you hear tales of the many frogs that have been sacrificed, in vain, to his rapacious maw. I believe a kind of mutual respect is engendered between angler and fish under such circumstances.

When our friends here have nothing better to do, they proceed to "have a turn" at the pike in the pool, and with exemplary patience sit and angle for him for hours on end—but in vain; and then, with a sigh of contentment marking the accomplishment of a duty, the anglers cease from troubling, and leave *Esox lucius* to his meditations. It is a great thing in life to have a perpetual pleasure in reserve. My angler friends in this respect owe a large meed of gratitude to the ancient pike in the pool. For how old he may be, nobody knows; and, what is equally to the point, nobody can venture to set any limit to his existence. Perhaps if human life could pass as quietly and uneventfully as does that of the pike in the pool, its all too short span might likewise be indefinitely prolonged; only they who choose the slow by-ways of life, miss the capacities for joy, if also they escape many sorrows. There is always compensation in living according to our own ideas, if only we can be got to see exactly how the land lies with other people. But if as to this particular "Ancient Pistol" of a pike and its ancestry history is silent, it speaks out clearly enough about other pikes which have attained fame in the pages of angling and zoological lore.

First of all, no one will venture to hazard a guess at the weight of the pike in the pool. He may be a twenty-pounder, or a thirty-pounder; and this estimate has been doubled in the case of big pikes which have been captured now and then. It is pretty certain that the pickerel, or pike perch, of the American lakes is but a baby-edition of our pike, as its name, indeed, indicates; while, when we come to consider such a giant of the pike race as the "Masq'allonge" of the great lakes of America, we see in it simply an overgrown edition of the pike before us. The name "Masq'allonge" is, of course, Canadian French for "long face," and the name of the American pike has been corrupted in its turn into "maskalunge," "maskononge," "maskilinga," and the like. The dimensions of this American cousin of the pike in the pool are, of course, as big as are those of the Britisher. A weight of 80 lbs. and over is given as that of a big fish, and its length may measure over four feet. The question of the pike's longevity, however, still waits us in the shape of the historic records already mentioned.

Even our angler friends advise us to take the records in question *cum grano salis*, or even with a good big pinch of the condiment. Here is the chief of the tales. A pike was caught at a place called Kaiserlautern, near Mannheim, in Bavaria. It was nineteen feet long (this is the point which requires "salting"), weighed 300 lbs. (another pinch, please), and was 260 years old—no more "salt" is needed. Whether or not this was the fish alluded to in another tale, or whether this second narrative is merely an improved edition of the first, I cannot discover. The salt cellar may be required again, but tale number two is highly circumstantial. There is nothing like giving details boldly, as the narrators of sea-serpents stories know full well. It seems that in 1497, some adventurous anglers in Suabia contrived to capture a pike. This fish had a ring attached to it, and on the ring was an inscription to the effect that it was put into the lake by the order of Emperor Frederick II. in the year of grace, 1230.

Apparently this is the same pike that figures in the first recital, for the coincidence of the 260 years of life, or thereby, is too marked to escape notice. The words on the ring were:—"I am the fish which was first put into this lake by the Governor of the Universe, Frederick II., the 5th of October, 1230." I am sorry to say the pike family gets a very bad name from our anglers for voracity (described as unbounded), for cruelty (described even more strongly), and for giving much trouble (if also sport) in its capture. For this last trait no reasonable being will hold the pike responsible, seeing that it is hardly to be regarded as a pleasurable excitement to be pulled about by the jaw with a big hook. As for brains, the pike in the pool and all his race is simply full of them—that is to say, his head-parts. He is cunning and wary, and when he has been hooked, the manner in which he doubles and twists, and continues to tangle the line and to rub it through by friction against the roots of trees and the like, evinces a play of brain power which is not to be sneered at because it is exhibited by a cold-blooded fish.

I have heard of sportsmen (American) who shoot pike from the banks or from a boat, but then our cousins across the sea are extremely fond of using their "irons" on very slight provocation, as everybody knows. Old Izaak appears to have had a singular fondness for the pike-family. He dilates at length upon them and their ways. Listen to a remark of Izaak's about the social features of the fish. "He is observed to be solitary and melancholy, and a bold fish; melancholy because he always swims or rests himself alone, and never swims in shoals or in company." By contrast with the pike, the herring must be a most socially-inclined fish. Then Izaak the Gentle goes on to say that the pike is "bold, because he fears not a shadow, or to be seen of anyone, as the trout, the chub, and all other fish do." This is in the main true, but the American pikes are more sociable, for they are often seen in shoals, and even the English pike unbends on occasion, for Yarrell says they come into the Cam in great shoals in spring.

Izaak Walton elsewhere gives directions, if I mistake not, for preparing a frog, nicely and satisfactorily, for the operation of trolling for pike, which is an exciting sport when all is said and done, and has the great advantage over purely scientific experiments with a frog in that you don't need to regard Acts of Parliament in your treatment of the amphibian. "Thus use your frog," says the gentle Izaak. "Put your hook, I mean the arming wire, through his mouth and out at his gills (but a frog has no gills), and then, with a fine needle and silk, sow the upper part of his leg with only one stitch to the arming wire of your hook, or tie the frog's leg above the upper joint to the armed wire, and (save the mark !) in so doing use him as though you loved him." All this you may do in the sacred name of sport, and no man may say you "nay"; but when, for knowledge sake, it may be, or for the discovery of some truth of value to mankind in saving life or in lessening pain, you wish to experiment on a frog, you will be debarred by Act of Parliament, and, what is much more important, you will be prayed for, as almost past hope, by the old ladies who represent zoophily gone mad.

But this also is vanity; only, it all arises out of the pike in the pool, who is as fond of frogs as a Gaul, who eats them whenever he gets the chance, and in so doing illustrates the cruelty of Mother Nature, who has declared that "life, by other life, must be sustained." There is no moral to this story of the pike in the pool, except, mayhap, that when we speak of pain in lower life we should be very cautious not to translate it in terms of higher life. You cannot credit the pike resting below in the water, with the human or higher-life enjoyments at large; why then credit it with the capacities for pain which to you and to me are matters of brain, consciousness, and all the other things that belong to the mental side of humanity?

CHAPTER X

Lobs and Flounders

Lower Largo in the Kingdom of Fife—The Lobworm and its Work—Fishing for Flounders—The History of the Flounder—Heads and Eyes—The Evolution of Flat-fishes.

WE are still vegetating in the East Neuk of the "Kingdom." The shade of the Serpentine Walk through the wood to that "sweet Auburn" of Fife, Upper Largo, clean, neat, and spruce as a new pin, is grateful to such dwellers in these parts as are not engaged in golf. By the sea, there is coolness no doubt, but it is the east wind that lessens the heat after a negative fashion, though the glare of the sun on the water dazzles even the strongest of eyes. Largo is busy to-day despite the heat and the east wind. There is bustle on the beach. The boatmen, who own a small but select fleet of boats, are doing a thriving trade. No sooner does a craft touch the beach than it is re-engaged on the spot, and is shot away from the slope of the shore into deep water with a fresh load of boys and girls and "children of a larger growth," eager for an hour's aquatic exercise. It must be dull enough by Largo Bay in the winter.

An ancient mariner confides in me to the extent of informing me that they spend the winter in Largo "grumbling at ane anither." But if the winter of his discontent may thus be described, it is clear his summer is lively and profitable, and his boats come and go, like Tennyson's brook, for ever.

The pier of Largo has also been lively enough to-day. It has been "paved with good intentions" no doubt, but it is a rocky promenade all the same, and wants another fifty yards or so added to its length to fit it for any purpose more useful than sheltering the fishing boats. Yet, at flood tides, a steamer may approach Largo with a spirit of confidence, and to-day a Galloway liner came alongside and took a whole tribe of Largoites round the Bass and back at a shilling a-head, with (I am credibly informed) a very liberal allowance of *mal de mer* thrown in for nothing. It is at the ebb of these big tides that the tangles which festoon Largo Bay, just outside the village shore, yield a rich harvest of sea-urchins or *Echini*. The boatmen on such occasions sally forth into the depths of the sea, and catch the "urchins" by the half-dozen as they feed on the seaweeds.

A certain genial Professor, who dwells "in the Wast o' Scotland," receives supplies of Largo Bay urchins for purposes of zoological demonstration, and very fine specimens these Fife echini may be said to be A sea-urchin is, of course, only a starfish, which has come to have its rays rolled together so as to meet at the top—at least this is a popular enough method of indicating the relationship which exists betwixt the urchins and the stars. When we have time and opportunity we shall examine more thoroughly the sea-urchin's shell, note its six-sided plates, see its five perforated rows for the protrusion of the same tube-feet wherewith the sea star walks, and discover the five big limy jaws which chew the seaweeds, and form the "Lantern of Aristotle," of the natural history class-room. And when, perchance, in the winter time you may seek to improve your acquaintance with the fowls of the air or the beasts of the sea (in a literary sense), this little demonstration of the sea-urchin's shell by Largo Bay will bear fruit, because things seen are so much more effectually remembered than things you have only heard about, or that you know by proxy alone.

The ancient mariner and I have made a tryst to go afishing this afternoon. The tide is on the ebb, and the venerable one tells me this is "a fine time for the fish." *Experientia docet.* I doubt not; and I do not gainsay the dictum of Largo. Early this morning the mariner was astir (attended by "Punch," our pug dog), "howking lugs," by which expressive Kailyard phrase it is to be understood he has been disinterring lob-worms from their sandy beds. You see the fruits of his labours in the tin at your feet as we are rowed out into the bay in the roomiest of the Largo fleet. In that old tin (which came from Chicago filled with minced collops, as its label tells us), there is a seething mass of worms. These are the "lugs" wherewith you are going to tempt the flounder from its lair, the gurnard from his repose, and the codling from the security of the deep.

Do you remember the legend of Michael Scott, the wizard? Michael made a compact with the Devil whereby the latter was bound to assist him in the performance of the many famous works and undertakings which are laid to the credit of the Scottish necromancer. At last there came a time when Michael became placed in a dangerous position, because his familiar, not having any work to do, threatened to overwhelm the wizard himself. Struck by a brilliant idea, Michael set the Evil One the task of spinning ropes out of sea sand; and, adds the legend, you may see the result of the Devil's labours after every receding tide. Michael's ropes of sea sand are, of course, the work of the lob-worms, which come up to the surface when the tide is in, but turn tail at its ebb, and burrow downwards, casting forth the materials excavated from their tunnels in the shape of the familiar coils you see on the beach. The ancient mariner digs down, he tells you, between a coil of the sand ropes and a certain hole which you discern about a foot off from the coil. The hole marks the worm's entrance to the sand, and the coil marks its terminus, and so between the two, as the spade goes down into the beach, you come upon the lob-worm, named scientifically *Areni* *cola piscatorum*, or "the sand-dweller which is used by fishermen for bait."

Pick up a specimen from the tin and lay it on the seat of the boat. Observe the big blunt head, most admirable of tunnelling instruments. The body becomes slender behind the head, and you are struck by the beautiful tufts of gills wherewith the sides of the body are provided for breathing purposes. Under the microscope, these feathery gills will show you the blood-circulation in a most typical fashion. They are loops of blood vessels wherein lob-worm blood is exposed (as is our own vital fluid) to the action of the vivifying oxygen. You may trace the digestive tube of the worm through the clear walls of the body, and you can also detect in a favourable specimen the pulsations of the big vessel in the back which corresponds in a manner with the lob-worm's heart. When the ancient one has baited your hook you will see his fingers stained yellow. This is the lob-worm's blood, which contains only yellow colouring matter, and thus presents a marked contrast to the vital fluid of higher life.

We let go our anchor fifty yards or thereby from the little yacht, which lies in Largo Bay snug and safe from the risks of shipwreck and storm. Our anchor is a twenty-eight pounds weight, which carries out our cable with a rush into the depths of the bay. Then we cast over our lines, well baited, some with lug and some with mussel, and wait and watch for the nibble that betokens the coming down of the finny tribes. It is in truth "a gentle art," this of fishing. Old Izaak was perfectly right when he so described it. It suits a man of dreamy, thoughtful nature exactly, and what is more to the point, it cultivates that tendency of mind in folks who are restless enough in the world's ways at other times and other seasons. Here, to-day, with a bright sky overhead, you are lulled into content by the lapping of the waves against the boat, and by the air of peace which environs you and steals its way into your inmost heart. Business and life's worries are all forgotten; enmities and animosities fade away from your mind; aspirations and yearnings are subdued; and every thought speaks peace and breathes the quiet of a contentment that is sublime. You might be in the lonely Pacific, as far as the worries of existence are concerned, instead of floating in Largo Bay half a mile from Robinson Crusoe land, and within sound of the train whistle which heralds the entry of the East Neuk "express" (save the mark!) into Largo Station.

But the mariner has had a nibble, and what is more, he has hooked his fish, and so in a second or two, a big codling, full two pounds weight, lies gasping and panting in the bottom of the boat. Another nibble, on my side this time, and I land a gurnard, big-mouthed, with its back fins erect and spiny, and its ventral fins working like the veritable legs they are, when you behold these fishes walking over the floor of an aquarium tank. The doctor from China, who has been holidaying it for a year in the old country (like a wise Oriental), and who is doing the *dolce far niente* in the stern of the boat, pulls up his first fish, a flounder, and joyfully rebaits his hook with the remark that a good beginning is half the battle; and the third man in the boat, as he pulls in another of the same, remarks that his "sole desire is ne'er to make a flounder" —which sounds like a line from one of Byron's burlesques. The fishing goes on merrily enough —nibble and catch—codling, gurnard, flounder—flounder, gurnard, codling—until a small octopus comes up on the hook, and is welcomed with a shout of delight as a *rara avis* for the Firth of Forth. It is a veritable cuttlefish this, which has been attracted by a mussel bait to its capture; and so we empty the mince-collop tin of its lob-worms, fill it with clear water, and watch our octopus between the nibbles and the hauls of our fishing expedition in Largo Bay.

The hours pass, and we are still a-fishing. Our quarry accumulates in the boat, and flounders, codlings, and gurnards lie before us in plenty, while the octopus in its tin pants and breathes in and out its water-jets with all the regularity of a well-ordered organism. I have resigned my line, and for me nibbles and catches are over and done with. The ancient one is content. He says "it's a grand catch," which is satisfactory enough. The doctor in the stern nods now and then, and dreams of Foochow under the benign influences of Largo ozone. The third man is inquiring from the mariner about Largo kirks and Largo ministers, and hears accounts of one friend of mine who is a "grand preacher," and of another whose empyrean flights of eloquence made him a celebrity in the East Neuk.

My thoughts wander off to the flounders before me in the boat. Curious fishes are those flat-bodied ones, which claim the sole and halibut and brill and turbot as their near kith and kin. Observe, they are not flat in the sense in which a skate is a flattened fish. For your skate is flat-bodied in a true fashion; in other words, it has a broad flat back (which, however, is largely made up of big breast-fins) and an equally broad under surface. The flounder with its neighbour and relatives are flat in the sense that its *sides* are more flattened than is the case with common fishes. The flounder lies and swims on one of its sides, which is light-coloured; the other side is dark-coloured, and it is the upper side. You are not to make the common mistake of supposing that the sides of the flounder or sole are the back and belly of the fish. Look at the white or under side, and you will see upon it the breast fin which, of course, is never seen on the lower surface of a fish; and the companion fin is to be noticed on the upper or dark side. What puzzles you, and makes you speak of the flounder's sides as back and belly, is the fact that both eyes of the fish appear on the upper or dark side.

Now, thereby hangs a tale, and a very instructive story of animal modification to boot. Our mariner has hauled up his anchor and is pulling away shorewards to where his father, with "Punch" the pug dog in attendance, is waiting to haul up the boat; so while we sail inwards I shall relate to you the romance of a flounder. When that flounder emerged from the egg it swam about properly, as every well-regulated fish does, with its back fin upwards and its sides in their proper position. It had its eyes where eyes should be, one on each side of its head. So far, nothing unusual was to be seen in the babyhood of the fish. In a little time, however, this deep body, like a crank ship, showed a tendency to overturn. The youthful flounder, in other words, instead of swimming straight, began to fall over and to rest on one side. That side was predestined to become the under side on which, as an adult fish, it rested before we hooked it this afternoon.

Next intervenes a curious and noteworthy experience. As the young flounder lies on its side, the eye which is below seems to contort itself, as if it tried to look round the corner of the head. This eye-movement proceeds, and is assisted in its intent by a curious twisting process of the bones of the skull. Ultimately the twisting and contortion accomplish their end, and we find the eye of the lower side transferred to what will in all the flounder's future be the upper side of the body. The flounder is thus an instance of an animal form which has undergone a very singular process of modification. It has inherited what was no doubt at first an accidental tendency in respect of the twisting of its head-bones, and that tendency has become stereotyped to form an unaltering feature of flounder-life.

There is more behind this story, of course. I might point out to you that the fact of your flounder beginning life with its eyes naturally placed is an evidence that "once upon a time" its race swam as do other fishes. This habit of swimming and lying on one side is an acquired and not an original trait of character. Certain other flat-bodied fishes rest on one side, but have not acquired the eye-shifting, head-twisting habit; yet in some of these fishes, we see that the two sides of the head are unequally developed. This is evidently the beginning of the condition which the flounders have finished with, and naturalists in days to come may find the ranks of the flat fishes strengthened by the accession of members possessing what are now naturally-formed eyes and heads. We are close inshore, however, and our pleasant lounge has come to an end. Some day soon, again we shall go a-fishing.

CHAPTER XI

On the Wings of the Wind

Dandelion-down and its message—The Composite plants—The dandelion-flowers — The seed and its history — Its settlement and growth—Winged seeds at large.

SITTING to-day in the shade, I saw the first of the summer's tributes in the shape of some dandelion down. This is a testimony to the extraordinary forwardness of the season. I do not remember to have seen the fruit of dandelion-industry so early in the year; but there it was, the delicate little parachute of cottony hairs, sailing hither and thither on the summer breeze, which, by the way, was light enough only to fan and kiss you, while it wafted the dandelion fruit easily and swiftly on its erratic way. The ripe heads of the familiar roadside flower will not be seen in plenty yet awhile, it is true.

On the principle that one swallow does not make a summer, so an early head which has run to seed quickly enough, may not induce the belief that autumn and the time of the golden reaping is near us just yet. The days fly quickly, alas! all the same, and the appearance of the dandelion fruit careering through the air reminds us that all in good time, and perhaps before we are quite ready for it, the day will begin to shorten and the long nights to creep upon us with slow but insidious step. I often wonder why the dandelion has not become a greater favourite with every flower lover. It is a pretty flower regarded from any point of view. If nobody had seen it before, and if it had been introduced into polite society as a kind of yellow chrysanthemum with a nice aristocratic name, we should all have gone into ecstasies over it, and the familiar plant would have been at a premium in Covent Garden and everywhere else.

Enthusiasts, remembering that dandelion root makes the various *Taraxacum* preparations of the druggist, have proposed its leaves for a salad, deeming it unfair that rabbits should have the sole monopoly of the herb. But as these same enthusiasts delight in nettles—which, eaten freshly-gathered, are by no means unsavoury—and as they go greater lengths still where ordinary minds (and stomachs) dare not follow, the dandelion gets left in the lurch as the despised weed of the road. It is a wonderful flower all the same, this "dens-de-lion," or lion's tooth, a name which, I presume, has been derived from the toothed edges of its leaves. In well-nigh every language of Europe, I fancy, the dandelion retains its significant name; but that learned gentleman, Professor de Gubernatis, thinks that the name is really connected with the sun, a lion being the emblem of the great orb of day, and the likeness of

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the flower to the sun accounting thuswise for its familiar appellation.

The dandelion belongs to a class of plants known as Composites, and a very fine and large family circle is this same group. It contains legions and cohorts of plants all modelled more or less on the dandelion and daisy type; and sunflowers and marigolds, lettuce, chicory, burdock, thistle, artichoke, chamomile, and the like are its near neighbours and allies. Here is a dandelion, growing like an intruder in the border of this flower-bed. Pluck it, and see how and why it and its tribe have received the name of Composites. You observe it is a "head" of flowers; that is to say, each dandelion represents not one flower but many. It is a colony of flowers, or "florets," as we may call them, all packed closely on the head of the flower-stalk.

Notice the circle of green leaves forming a kind of cup below. This you might mistake for a calyx such as you see in any ordinary flower. It is not a calyx at all, for the plain reason that you could not have one calyx doing duty for a couple of hundred flowers or more, and besides, each little floret in the dandelion-head has its own calyx, as we shall presently see. The green leaves are what botanists call "bracts." Ordinarily they protect the flower-bud, and are simple leaves; here they unite to form a kind of cup which environs and protects the colony of dandelion-flowers. An important cup too it is, for it closes up or opens according to the ways and wants of dandelion-life, which are various.

Observe that daisy growing close by us. It also is a Composite, of course; but you observe its florets, instead of being all one shape and all one colour as in the dandelion, appear in a double dress. The outer florets of the daisy are white, and the middle ones are yellow. The explanation of this difference is easy. The "wee modest crimson-tipped flower" has got on in the world rather better than the dandelion. By this I mean, in scientific language, that the daisy belongs to a more complex and specialised type of flower than its yellow neighbour. The white florets of the daisy, I suppose, act as flags and signals to the insect tribes that come to fertilise it, and find a free breakfast-table in return for the services they render to the flower. Yellow and white are more of a contrast than plain yellow, and the daisy ranks as a kind of composite aristocrat, while our dandelion if not quite settled among the "masses," is at least not of the Composite "classes," to quote the idea of a celebrated political authority renowned for drawing distinctions of superlatively subtle kind.

The dandelion before us is on the way towards maturity. I say "on the way," for you observe all its florets are not yet fully developed. Those at the edge, as you would expect, are further on than those of the centre of the flower; and this also is a little dodge on the part of Dame Nature, for when you want to attract insects it is clear you must "hang your banners on the outward walls," and not keep them concealed in the very heart of your citadel. Pull out one of the expanded and ripened florets of this strange flower-colony. You observe it is a little yellow strip of a flower, which is cut into teeth at its tip. This teaches you that the yellow strip is really a corolla, that it corresponds to the yellow leaves of a buttercup or a primrose flower, and that it is composed of five united petals.

Now glance down at the foot of the little yellow floret you hold in your hand. The cottony down at its foot is the calyx of the floret; only, as you see, in place of being a green cup it is a mass of fine hairs. This is what the botanist calls "pappus," and its use and service in dandelion-life you will see by-and-bye. Notice next, that the lower part of the dandelion floret is a tube; and out of the tube you see rising a little stalk with a cleft head. That is the pistil of the flower, and below the stalk is the seed-vessel, with a single seed within it. It was this seed-vessel which you saw careering on the wings of the wind a few minutes ago, and the parachute which bore it gaily along was nothing more nor less than that downy calyx which lies modestly concealed in the flower till it is needed to spread and diffuse the seeds over the face of the earth—

> "Each invisible and mute
> In this wavering parachute,"

as Wordsworth might have said, although the dandelion seeds are not certainly invisible, but are very much in evidence indeed, all in their due season.

When our dandelion has opened out all its florets, and when the florets have been fertilised, then comes the time of the seeds and their dispersion. I name them "seeds," but in reality each so-called "seed" of the dandelion is a fruit with the seed inside it. If, therefore, we may still for convenience' sake call them seeds, let it not be said that I tripped in my botanical teaching, and failed to warn you that they are really fruits. Now, when the seeds are getting ready to start on their mission of continuing the dandelion race in time, we observe that the green bracts outside the flower-head close up just as they do when it is cold or when night comes on in the flowering time.

This is like the act-drop's descent in the middle of the play. For there is a good deal of preparation going on within the dandelion-head before the seeds can be got ready to start on their aërial course. Closed up, then, is the flower-head for a time. When it opens, we begin to see the stage-carpentry which has been in progress in the interval of the botanical drama. The top of the flower-stalk itself has become swollen and rounded. Before it was flat or hollow; now it is a cushion, off which the seeds will easily be carried away. Then we find the cottony calyx has undergone a fuller development. It appears now on the end of a stalk rising from each seed as a veritable parachute, with its hairs spreading from a centre. Thus crowned with its feathery tufts, each the parachute which is to waft a seed onwards to its unknown goal, we get the dandelion-head of the autumn and late summer days. This is the schoolboy's clock :—

> "Dandelion, with globe of down,
> The schoolboy's clock in every town,
> Which the truant puffs amain
> To conjure lost hours back again."

Then, also, the flower-stalk itself straightens its back, so to speak, so as to give every chance to the passing breeze; and if the weather be wet and unfavourable for the dispersion of the seeds, the stalks of the parachutes will themselves contract so that no waste of material may occur owing to adverse chances of wind and weather.

Thus armed at all points, let us suppose our dandelion seed is liberated by the friendly breeze. Away it goes into the air, borne by the feathered parachute, over hill and dale, resting a moment, and then off again, like the will-o'-the-wisp thing it is. But a closer study of the dandelion seeds themselves reveals certain peculiarities as worthy of note as is the means for securing their diffusion. The seed itself is provided with sundry little hairs of tolerably solid nature. It is a safe guess to assume that these hairs serve an opposite purpose to the parachute. That appliance wafts the seed in its aërial journey; the hairs, on the contrary, arrest it. They are to the seed what the anchor is to the balloonist. When the seed does descend to earth, it is all-important that it shall not be at the mercy of the winds which blew it into its safe haven.

The list of nature's "dodges," however, does not end here. It might be an advantage to our dandelion seed did it get rid of its parachute when it had safely alighted on Mother Earth, and found a resting-place wherein to accomplish its appointed end. But the pappus-crest does not drop off at an early stage of things, as is the case with some other plants which diffuse their seeds in like manner to the dandelion. What happens to the parachute is noteworthy. When the seed has alighted on the soil, the hairs fold together somewhat, and thus present a striking contrast to the outspread condition in which they carried the seed on the wings of the wind. The little seed itself is meanwhile by no means passive in the matter of finding a secure resting-place. It has burrowing properties of its own which it does not fail to exercise, and so insinuates itself under the earth and between the grass-blades, or other obstacles it may encounter in its desire for settlement. When thus anchored in the soil the seed is at rest, the parachute and its stalk together soon die away, leaving the buried germ to lie dormant till the returning spring calls it forth into newness of life, or to germinate at an earlier period, and so to fulfil the mission wherewith it was credited in the great purposes of living nature.

Of course, our dandelion is not alone in this possession of a parachute. Thistle-down is as well known as dandelion-down; and if time permitted I could tell you of flowers which have two sets of fruits, one with parachutes and one without. This is evidently a cunning provision for securing a fair progeny for the replenishment of the home ground, and for likewise ensuring the success of the plant's emigration schemes. That lime tree over your head in a week or two will develop its winged seeds, and the maple beyond will show you a double-winged fruit in its turn. The fruits of the sycamore and the ash are also winged, and the diffusion of their seeds is secured through Æolian agency, if in a different fashion (as to details) from that in which the dandelion peoples the earth.

An Australian friend tells me of a grass of that land which lets go its flowers in the form of a big rounded head, which is driven for miles and miles over sandy wastes till it strikes a damp soil, when it anchors itself, expands, and distributes its seeds. These are a few of the contrivances which suggest themselves from the consideration of the dandelion-down.

George Eliot says that "nettle-seed needs no digging." Very true; like most other things undesirable in the moral life, it needs no cultivation. But the dandelion is a milder plant than the nettle, and its seed digs its own way by a process of cultivation both unique and effective. The workshop of nature is full of such contrivances for securing the welfare of her toilers, and, now that the day's heat is over, you and I may resume indoors the discussion of some of the problems which more nearly concern the support and nutrition of the frames we call our own, and whose own processes are more wondrous and more complex than any that are seen in the history of the dandelion-down.

CHAPTER XII

About Colour-Blindness

The eye as an optical instrument—Defects of sight—The colour sense and its nature—The eye in relation to colours—Colour-blindness and its nature.

THE defects which are liable to become apparent in the structure and functions of the human eye are, needless to say, many in number and varied in character. They depend on a multitude of conditions such as often require the highest skill of the oculist to detect and to cure. Readers who have dipped into the literature of this interesting subject may remember the remarkable declaration of Helmholtz, who averred that the human eye itself was an optical instrument, susceptible of much improvement. Judged by the strictest of scientific canons, the eye was found to present to the view of the physicist an instrument which exhibited defects of more than one kind, and of more than trivial nature. Read in another way than that which shows this declaration in the light of a quarrel with nature's handiwork, it may possibly be owned that the human eye is not an optical instrument capable of serving every demand its possessor might make upon it in the way of sight.

Man's eye is not capable of seeing so far as, say, the eye of the eagle, just as his sense of smell is vastly inferior in delicacy to that of the dog. All the same, man's sensory organs exhibit a very fair amount of development all round. In the case of lower animals a sense here or a sense there may be found to be specially acute, to the exclusion of other senses. Humanity's "gateways of knowledge," on the contrary, attain a very fair level of development throughout. If we add to this fact, the pregnant item of a brain which realises intellectually through the senses many things which the lower animals cannot possibly appreciate at all, we may confidently leave Helmholtz with whatever of satisfaction he may scientifically derive from his demonstration that our eye is not all an enthusiastic oculist could wish for or expect.

Of course it is undeniable, at the same time, that civilisation materially affects the sight-powers, and often induces serious changes in the natural structure of the eye, rendering it liable to alterations which militate against its perfect service as an organ of sense. Short-sightedness is thus a condition said to be markedly on the increase. In Germany especially, children appear to suffer from this condition to a serious extent, and there seems reason to fear that inheritance plays some part in the propagation of the defect. Short-sightedness primarily takes its origin from the fact that the eye-ball is elongated beyond its natural dimensions. The lens of the eye, to changes in the shape of which our power of accommodating sight to far and near objects is due, is also apt to be too convex, and the retina (or nervous network of the eye) is placed too far from the lens itself. Thus the parallel light-rays become focussed in front of the retina in place of upon it, so that far objects appear blurred and indistinct. The concave glasses which are used by short-sighted persons are thus seen to cause divergence of the light-rays, so as to prevent them coming to a focus before they reach the retina. It is the opposite with far sight, of course, because then the eye, in place of being too long, is really too short, and its lens, instead of being very convex, is too flat. The light-rays are focussed behind the retina in a long-sighted person, in place of meeting in front as in the opposite condition, so that convex glasses naturally correct and remedy the long-sighted condition.

There are other sight defects of less easily appreciated character to be noted as concomitants of our civilised state. Thus one eye may exhibit a different sight-power and accommodation from its neighbour, and there are conditions known to oculists in which alterations occur both in the matter of variations produced by degrees of light and in the matter of colours. The question of the colour-changes which are naturally exhibited by the eye is a complex but highly-interesting topic. We know, to begin with, that images are fixed, as it were, on the eye's sensitive plate or retina by a chemical process affecting the "visual-purple" or colour found in the outer parts of the rods whereof the retina is in part composed.

This eye-purple gets bleached through exposure to light, but seems to recover its tone in the dark, while it is variously affected by other than white light rays. This curious fact would seem to bring the act of seeing into still closer chemical relationship with the photographer's art. It is, however, certain that the images of white things leave on the retina white spectra or impressions, while those of dark objects are similarly of a dark character. Again, colours we see in nature appear to be represented in the eye. Such colours, however, do not correspond with those of the objects themselves, but with what physicists call their "complemental colours" or opposites. Thus the complemental colour of a green object is red, that of a red object being green. Violet gives yellow, and yellow violet, as the complemental hues respectively.

Physiologists explain this fact in an interesting fashion. When we look at a red object, and the retina receives its special light waves, the tendency of the eye's nervous network is to become strained or wearied by the reception of the rays in question. It remains sensitive, however, to certain different rays which go to form white when combined with red; hence these latter rays coming from a white object give rise to the green spectrum. In the same way, if green rays from a green object inpinge upon the retina, it is the red rays which replace the green when the whole object is looked at. The fatigued and wearied condition, physiologically speaking, of the nervous network of the eye produced by yellow light-waves gives rise to the sensation of violet. Orange and blue rays abound in the same relation as do the green and red rays.

More complex are the results produced by the action of different parts of the retina upon one another. If a coloured object is beheld lying on a white background, and be steadily regarded for a time, we gradually lose the image of the former, and the white part alone remains perceptible. Here, probably, the white and larger body exerts a dominating influence over the whole of the retina in opposition to the comparatively small surface of the latter which is affected by the coloured object. Again, where two parts of the retina are differently affected in vision, the one part may modify instead of obliterating the other part. A grey spot on a white background is thus made to appear much darker than is the case if the grey patch were alone visible. It is also notable that where one colour obliterates another (as in the case of the coloured body on the white ground) the process is a gradual one; while it is rapid and instantaneous where the grey tint deepens in contrast with the white.

But just as the ear possesses a complicated sounding-board containing rods or hairs which vibrate in response to different tones, so the eye is found to contain in its retina elements or structures, each of which is sensitive to certain colours and indifferent to others. It seems proved that the outward parts of the eye's nervous network are insensible to red, while as regards the retina at large, it has been apportioned out as showing areas which in turn are sensitive to red, green, or violet. Dalton, the famous chemist, having been colour-blind, and having been unable to distinguish colours, this condition of matters has been named "Daltonism" in consequence, while as "colour-blindness," the defect in question is perhaps more widely known. What occurs in such cases apparently, is a want of development of the special parts of the retina used for the distinction of colours.

Mr Bickerton, in a learned paper on this interesting topic, gives a number of most important facts regarding colour-blindness in its ordinary and professional or trade relations. It is specially noted that a colour-blind person is unable to distinguish the quality of the light that falls upon his eye. His brain is able and willing enough, but his eye so far, is weak and imperfect. The brain is not presented with the colour impressions in such a fashion that it can realise correctly and intellectually what has been seen. The degree in which this defect is present varies greatly. Certain persons are completely colour-blind and can therefore distinguish no colours whatever; but it is somewhat startling to read the scientific declaration that the majority of us are troubled with a mild and modified degree of this affection. While to the totally "Daltonic" person all colours appear to be black, white, or grey —a rare occurrence, it may be added—very many of us cannot accurately determine the nicer shades and tints of composite and complex colours.

It is notable also that yellow is the hue which is most easily recognised by "Daltonics," and blue comes next in order in this sense of easy perception, especially if this colour be very brilliantly illuminated and distinctly seen. The sight of the colour-blind may otherwise be good and strong, contrary to popular notions, and the perception of colour thus appears to depend upon conditions utterly different from those which regulate vision in other of its functions. It is also a fact that along with Daltonism there may exist a very delicate sense of difference between the relative intensities of two kinds or sources of light.

The cause of colour-blindness, as we have seen, is to be referred to a want of due development of certain structures in the retina. These structures consist of what anatomists call "rods" and "cones," and it is assumed that the cones are really the parts which are at fault when Daltonism is present. In night-hunting animals, to which a sense of colour would be least useful, the cones are absent from the eye, while the rods are well developed; and this fact would, therefore, appear to support the view of the responsibility of the cones for the affection. Those persons who are typically blind to colour have always a difficulty in distinguishing red, while, of course, the complementary colour, green, already alluded to, is likewise in abeyance as a recognisable hue. The want of power to distinguish the one colour from the other is, to begin with, a prominent feature of Daltonism as ordinarily met with. Red, green, and violet are the ordinary results of the eye's analysis of light, while the colour-blind eye simply distinguishes two elements, "neither of which," says Mr Bickerton, "is red."

Apart from its scientific interest, colour-blindness, as already remarked, carries with it serious considerations from an economic standpoint, for the ability to distinguish colours is, of course, a matter of paramount importance with engine-drivers, signalmen, pilots, sailors, and others, occupying positions which entrust them habitually with the safety of many human lives. Nor is the gravity of the condition with reference to human safety lessened when we reflect that colour-blind persons are not personally conscious of their sight defect. They do not know that there is any difference in their view of green and red from that which exists in other and normal-sighted people, so that the necessity for accurate testing of the sight of public employees, is a matter calling for the most imperative and strict attention on the part of all who have to deal with the engagement of responsible officials.

It is not denied that colour-blindness is an affection which runs in the blood—in other words, that it is an inherited and congenital condition; while it is important to note that an equal agreement exists in respect of the statement that it is unalterable and incurable, because it is dependent on a fundamental structural defect in the eye. The frequency of this affection has been variously stated. It has been, perhaps, correctly enough set down as existing in three or four per cent. of the adult population. Thus, out of 32,165 men examined 1019 were colour-blind, giving a percentage of 3·168. Out of 18,556 men, 764, or a percentage of 4·117, were affected. A third investigation gave 617 Daltonics out of 14,846 men, or a percentage of 4·156. The mean or average percentage of the three sets was 3·66. Men, curiously enough, are more liable to exhibit colour-blindness than females. In 14,557 females only 11 were found to be colour-blind, but to what condition this superiority on the part of women is due it is impossible to say.

One author holds that a superior colour-perception on the part of the female has been transmitted and intensified. The naming of colours has been credited with giving us too high a ratio of female excellence in this respect, as opposed to the distinction of colours; it being assumed that women have more to do with the selection of colours in common life than men. If the condition is an inherited one, then possibly evolutionists may be able to explain the female superiority in this respect by a reference to those far back ages when "selection" of their partners by reason of fine plumage and rich colour, was, theoretically at least, a marked duty and privilege of the weaker sex.

At present it is estimated there must be 4000 seamen colour-blind in the British mercantile marine, not taking into account pilots and other grades; hence tests have been defined by the Board of Trade, since 1877, for persons desiring masters' or mates' certificates, with the view of proving their capacity to distinguish colours. But even if the master or mate fails to pass this test, he can still go to sea possessing a certificate endorsed to the effect that he has "failed to pass in colours." Certain naval authorities seem inclined to limit greatly the gravity of colour-blindness as a cause of disasters at sea; but it seems impossible to suppose that a colour-blind seaman or pilot can be regarded as other than a really blind guide, when at night it is a question of lights and lights alone—red and green—which settles his course.

While in Holland the examination of sailors is made by experts, in England, it seems, the tests are applied by those who do not pretend to any professional knowledge of the eye and its defects, although Mr Bickerton tells us that Liverpool shipowners, at least, seem to be fully alive to the danger of entrusting ships to the care of colour-blind officers. The Royal Society, through a committee, instituted a thorough examination of the tests for colour-blindness; and it is to be hoped, as the result of this committee's reports on its labours, public opinion will force on a satisfactory solution of a question which clearly has the most intimate bearings on the safety of all who travel by sea, and of the millions who travel by rail as well.

CHAPTER XIII

Living Beings as Chemists

The chemistry of the living and the non-living—The plant as a chemist—How it elaborates the living out of the non-living—The animal as a lower-grade chemist—The interchange of Nature.

IT has always been a hope of the chemist that one day he may be able to build up from the simple elements or compounds at his hand, those more elaborate bodies which are specially associated with life and living things. It is not so much of a forlorn hope this as many of us might be tempted to think; for chemistry has been able to do not a few very startling things of late years in the matter of this reconstructing or building-up work, as indeed I showed in a preceding chapter. A brief review of the difficulties of the chemist's task when he undertakes to investigate the nature of the changes and actions which are characteristic of life may form an appropriate introduction to our consideration of the chemist's art *in excelsis.*

First and foremost, it is found that while non-living things are, as a rule, composed of many elements, the compounds formed by the combination of these elements are usually of simple character. They are built up of two or three elements, and their nature is easily determined; while another important point about non-living bodies is the constancy of their compounds. These last are stable things, and show little or no tendency towards spontaneous change. Now, the compounds which build up animal and plant bodies display the opposite characters. They are complex in nature, and are made up of a multiplicity of elements, which are present in high combining proportions. Again, when we are dealing with living substances, or with the substances made by living things, we notice their tendency to alteration. They are unstable things, seeking, as it were, to become something else.

The very essence of life is change, and chemical change is well represented in living history. Processes which go to renew the living body and to give it matter for growth illustrate such changes in a very apt fashion. Still more aptly does the progress of decay and death exemplify the curiously inconstant and unstable nature of the chemistry of life. For as the work of life goes on, all its actions are accompanied by destructive changes to the body which lives. Its compounds are breaking down into simpler things. They fall from their high estate, and descend to the lower level of the non-living world. Thus, living matter or protoplasm is a curiously unstable compound of complex nature, belonging to a class of substances called *proteids*. Now, these proteids consist of carbon, hydrogen, oxygen, and nitrogen, with traces of sulphur and phosphorus. This is a complex composition, to begin with, and it is part and parcel of the vital chemistry to build up such compounds. Yet, mark the result of living instability. As a consequence of life's work, the body which lives, is perpetually changing, and incessantly being broken down into water, carbonic acid gas, ammonia, and other bodies of far simpler composition than itself. The wear and tear of an animal body, in plain language, consists of matters which properly belong to the non-living world. "Death," in a chemical sense, is just as clearly a picking to pieces of the living machine as, in a material sense, the end of life means and implies the actual disintegration of the once living frame.

There is, however, a very important difference to be noted between the chemical work of an animal and that of a typical plant. By a typical plant one means an ordinary green-leaved organism and not a groundling without green, of which a mushroom is an example. For those that have no green colour, live more like animals than plants, and, strange though it may appear, a low fungus is in some respects nearer man in its vital chemistry than the lordly oak or stately beech. Excluding the fungi, therefore, and any green plants which (like the mistletoe) happen to prefer to sponge on other plants for food, and those also which devour and digest insects, we find the typical plant with a chemical history all its own. It is a marvellous constructive chemist, and every living cell of its leaf is in its way a very admirably constructed chemical laboratory. First of all, consider of what the food of the green plant consists. There is the highly essential water, without which all life parches, droops, and dies. Then come minerals which are dissolved in the water.

Next succeeds carbonic acid gas which the leaves inhale from the atmosphere, and finally we must reckon with ammonia, which, as a kind of tit-bit, the plant demands for the completion of its bill of fare. Looking over this list of food substances, what is the idea we get regarding the diet of the green plant? The reply is, that the dietary in question consists of non-living matter. Water, carbonic acid gas, minerals, and ammonia are one and all non-living matters derived from the air and soil. Now mark what the plant makes of these inorganic substances. It appears on the scene as a constructive chemist. It is not an analyst, but rather a builder-up or a "synthetical" worker, as the technical expression for making compounds out of their elements has it. Supplied with its modest requirements in the way of food, our plant-chemist elaborates them into much higher bodies.

Out of its non-living food, first of all, it makes its living protoplasm. Out of the water and carbonic acid gas it will elaborate the starches and sugars and other matters which are so characteristic of plant-life. From the materials of air and soil, we get built up the beauty of the blossom, the greenness of the leaf, and even the delicious scent of the flower. This is a piece of living chemistry which may well excite our wonder and admiration. Behind it all there is, of course, the mysterious "life" which directs, guides, and initiates the work, but none the less strange is it that the green plant builds up all its structures and organs and parts out of the non-living materials supplied to it by the earth and the air. It is in very truth a "vitaliser" of typical kind, since it constructs its living tissues out of that which is not living in the world around it.

With the animal, the case is very different. There we approach at once a higher type as regards living action, but a lower type as regards constructive chemistry. The animal life, on the whole, is more complex than that of the plant. Its functions—digestive, nervous, and the like—are often unrepresented in the plant, and its existence is of more complicated type, taking that existence in a general sense. The nervous functions alone raise the animal markedly in the living sphere above the plant; so that it is to the evolution of the nervous functions, probably, that we owe most of the characteristics of the animal world; and this view of things becomes the more reasonable, seeing that culminating in man and his allies we get the powers that relate him to his surroundings as the conscious, intelligent, aspiring being. But when we come to consider what the animal does as a chemist, we see that it falls far behind the plant in its constructive ability.

For, essentially, your animal is a puller-to-pieces and not a builder-up. It is a vital analyst rather than a constructor in a chemical sense. Study the animal food and feeding and we shall discern this plain fact. First of all it demands ready-made living matter for its support, since it cannot, like the plant, manufacture living stuff out of that which is not living. Its food consists of water, minerals, oxygen gas (which are all non-living matters no doubt); but, in addition, the animal is helpless as regards its ability to live unless it has already living matter supplied to it. Put plainly, we see that an animal must eat either other animals, or, if it is a vegetarian (like the cow), it may eat plants; or, if a mixed feeder, it will subsist on animals and plants both. It has no power to make new living matter of its own out of non-living substances like the plant; and is thus a Sybarite of the first water, when we compare it with the more or less Spartan rigidity which characterises the plant's *menu.*

The plant therefore appears before us as the typical purveyor in Nature. It represents the commissariat of the animal hosts. On it animal life depends; for, in truth, we are all vegetarians in an indirect sense, whether we esteem the products of the butcher's shop or not. The tribes of vegetable-feeding animals go directly to the plant world for the living matter they desire and demand. But even the flesh-eaters can be shown to be dependent on plants. For when a man eats a beef-steak he is only devouring so much ready-made matter that the ox elaborated for him from the herbs of the field. And so in a new, but not less practical, sense, we get a confirmation of the old saying that "all flesh is grass."

This inferiority, in a chemical sense, of animals to plants, however, is equally well demonstrated when we come to consider the results of animal life. We have already seen that the animal body, as the result of its living wear and tear, is breaking down into tissues of matter which are chemically simpler, and therefore chemically lower than itself. Bear in mind that the plant is ever building up its frame from simple matters into those which are chemically more complex than its food. The animal frame is perpetually breaking down into water, carbonic acid gas, ammonia and minerals, and those things are given off as the actual waste of the body. So much, indeed, is matter of elementary physiological study.

There is another substance, called urea, which is found as part and parcel of the animal waste; this substance representing the chemical breakdown of the more typically living and vital tissues. Now, glancing at the water, carbonic acid gas, and other matters given off by the animal, we at once see that these are non-living in their character. They represent the distinctive result of the animal's chemistry. Matter is turned from a higher to a lower level by the animal body, whereas by the plant matter it is elevated from a lower level to that of living substance. Again, we see clearly enough that the very things into which the animal body is breaking down represent the substances on which plants feed. There is a kind of friendly and philosophic interchange in this matter. What the animal gives off, the plant takes in; and what the plant manufactures, the animal demands and requires. There is represented here a very natural and interesting cycle of operations, whereby the one group of living things becomes complementary to the other.

It is really an old story this which is taught us by the weaving together of the chemical interests of animals and plants, and that story is simply the inter-dependence of life all round. Nothing in nature stands alone; on the contrary, each organism is related more or less closely to other living things, and inter-dependence, not independence, is the order of the day. In the life social it is the same. Not the least important result of the story of living chemistry may be that of showing anew how, in an unbroken chain, the interests of all grades and classes are inextricably bound together—the interests of one grade overlapping, and often including, the welfare of many others.

CHAPTER XIV

On Finding the Way

Human and animal migrants—The limitation of senses—Is there a sense of direction?—The utility of such a sense.

THE birds are beginning to take their journeys south, away from the chill and cold, to the warmth and sunshine of the tropical and sub-tropical regions. Certain lucky mortals among us can go and do likewise; the big majority of us (like the robins), have to stay at home. I envy those happy folks who fly away by the *train de luxe* with its *wagon-lits* to Nice and Cannes and San Remo and Monte Carlo and adjacent parts. I don't as a rule envy anybody, or covet the ways or opportunities, far less the goods and chattels, of my neighbours; but I confess I look with longing upon Smith, who sets off for Algiers; or upon Brown, who thinks he will winter at Cairo, and do a little (it will be a very little) in the way of interesting himself in Egyptian archæology and the discoveries of Mr Flinders Petrie.

We here have to remain cold and chilly all through the autumn and the winter and the abominable spring, and all for a small bit of summer, which is never up to time, and for a *soupçon* of nice days in good old September, which I have long recognised as the one reliable month of the whole twelve. Smith and Brown will be revelling amid the palm groves and the cactuses and the violets when I am blue-nosed as a mandrill—a beast that I take the liberty of saying is second to none in creation as regards its cerulean physiognomy. This is not fair—excuse one grumble at least, for it relieves the soul of much tribulation—and the only consolation is that Brown and Smith will be far away from "bears" and "bulls," and will have to learn from a three weeks' old newspaper, who is hatched, who is matched, and alas! who is despatched among their friends at home. We have also our consolations in that Smith and Brown will be tormented (at Cairo especially), with certain insect pests that happily are unknown here even in the hottest of the summer days. They will growl and grumble at everything foreign until somebody reminds them that like Bailie Nicol Jarvie of pious memory, they "canna hae a' the comforts o' the Sautmarket when they veesit their friends i' the Hielan's!" So all things considered, though I should not object to a month with Smith (a fortnight would be quite enough with Brown and Smith combined) in the halcyon groves of San Remo or Nice (with a wicked little "flutter" in prospect at Monte Carlo), I am perhaps as well off at home even with the snow and the frost, and even with that beastly and soul-dispiriting fog that gets into your bronchial tubes, and takes days and weeks of clearing out, even in a purely Pickwickian sense.

There is another thing to be mentioned. When Brown and Smith once begin that autumnal departure of theirs in the track of the swallows for the south they have got to keep it up. You and I are old campaigners, and we withstand the frost and snow. But when Smith thinks he will winter at home, Professor Mitral, M.D., will warn him that he is a sub-tropical kind of bird now, and must migrate as of yore. When Brown imagines he is going to stay at home all winter to see his eldest daughter proposed to by young Micklewhame, and to settle the whole thing right off in one short season, Dr Danderson, F.R.C.P., will have no such dallying with Providence. The doctor tells Brown he is no longer acclimatised to home in the winter season, and poor Brown must needs pack up once again and set off to the south if he is to escape the bronchial ills that once he resisted firmly enough, when he used to trudge down every morning from the suburbs to the city and defy all the elements the old country ever imagined or contrived in the way of weather.

So you and I may rest content with our catarrh and our little bit of rheumatics in the "off fore-leg," or even that tendency to bronchitis which plays havoc with us now and then. Things might have been worse—much worse; and Smith and Brown are only *our* summer visitants, and expatriated citizens to boot. What set me thinking about these nice little autumnal journeyings to the south was the fact of bird-migration being represented fairly and fully in our midst, and this in its turn sent my thoughts off at a tangent on the question, "How do birds manage to find their way at all in these long, weary migratory journeyings?" And not birds only, but other animals as well, and even men themselves may direct and guide their footsteps sometimes in a very marvellous, if also unconscious fashion.

Of course, the migration of birds is a big subject in itself. To explain that, you have to go away back to the glacial epoch or great ice age, and perhaps even beyond its range and duration. You have to think of different dispositions of land and sea, and of a long-existent habit on the part of the migrating birds (persisting onwards to our own day), of finding their routes as naturally, in a way, as the newly-hatched chicken, born on a carpeted floor, begins at once to scratch the ground for its food. It is a wonderful study this of inherited instincts. The bird is an unconscious agent in the hand of the ways which have operated to govern its comings and its goings from the far-back times. There is inherited memory, all unconscious of what its ancestors did in the past, and this memory is as much part and parcel of its constitution as are its feathers or its bones. Think of birds flying over thousands of miles of sea without a sign to indicate the road. This alone would be an insoluble problem of animal guidance; but it becomes easier of solution somewhat if you may picture to yourself a state of things when the passage that is broken up into sea and land to-day was all land together.

Over this land-area birds would pass to and fro easily enough. It would be all known ground to the race or races frequenting it and traversing it. Then when the big cosmical changes came, gradually, let us suppose, or at least not with cataclysmal force and suddenness, the birds would bit by bit become accustomed (as a race) to the new order of things. First a little bit of water to cross, and then a wider and wider area of sea between the land points; but, all the same, the journeyings, guided by previous knowledge of landmarks perhaps, and of the route at large. And then the disappearance and alteration of the land succeeds, and "there rolls the deep where grew the tree." Yet the instinct of direction remains fixed in the race. A new illustration of use and wont, it may be, but one which derives its greatest force from the fact that it explains what we really see.

The wider question, "have other animals (including man) a sense of direction?" is possibly more interesting than the bare details of bird-migration and seasonal flight. Of course, everybody will be ready with examples by the score of cats and dogs, taken from their homes in closed baskets, liberated amid new surroundings, and then finding their way back again after a few days of apparently direct and toilsome travel. There is no disputing these facts. They are known to all who have had anything to do with cats and dogs in the sense of studying their ways. Yet if there is represented a sense of direction here, I frankly confess I scarcely see how it is exercised. Such a sense must have some data to go upon. What data has the cat or the dog? It cannot be a sense of compass-bearings or directions, for that would imply the work of the sailor in taking bearings before he set out; nor can it possibly be a knowledge of landmarks, for the cat or dog is in a new country, and has never seen anything of its new district before.

How then does it find its way back to its home? It cannot be contended that smell has anything to do with the animal's return; for that return may take place after a fifty-mile ride in the train. What, then, I repeat, is this "sense of direction," of which one hears so much glib talk now-a-days? Let us pin down our talkers to the bare facts, and ask them to explain them, or themselves—so many people have quite a comfortable way of getting out of a particular difficulty under a piece of generalised nonsense, not to put too fine a point upon it. It is far better to say simply "I don't know," than to badger oneself or other people with an attempt at explaining what it is not in our power, as things are, to make clear. Only, very many of us have not the courage to act up to the "don't know" stage of philosophy; and it requires some fortitude, I confess, to pose as a kind of tacit ignoramus in select circles where everybody knows all about everything.

Theories about "direction" and this mystic sense you will, of course, get in plenty. "It's a knowledge of landmarks, don't you know?" said a friend to me the other day, when by the side of the big cool pond at the Hague, he and I sat smoking the pipe of peace, and looking at the swans circling round the green island in the middle of the pond. We had had a little experience that day which justified my friend's opinion so far, but which will not explain the cat's or the dog's return to its home. "Where is the Post Office at the Hague?" said he. "I know it, and I think I could take you to it," said I, "though it is four good years since I set foot in La Haye. If I mistake not," I continued, "we will find the Post Office through that fine old arch up yonder, and we will turn to the right, across the square, and up a narrow passage—and *le voilà*." And so we went, and I guided him and myself unerringly to the very door of the Post Kantoor, as the worthy Dutchmen style their G.P.O.

Now here, of course, you will say, "this is after all only a knowledge of landmarks." True, but do you suppose my knowledge of the Hague byways was a matter to which I had given any attention at all? I had no consciousness of being able to succeed in my quest. What I said to my friend was said more as the expression of an intuition than as a boast of a well-ascertained power. Yet it came off all the same; and I suppose a sense of locality, which is only another name for the unconscious remembrance of landmarks, and above all, for a memory strong (as I admit) even in its unconscious operations, led my friend and me to the Post Kantoor. In man, I suspect, the remembrance (conscious or unconscious be it remarked) of landmarks, is at the bottom of the relatively small things we do in finding our way about in places where we have been before.

A shop sign, a peculiar stone in a wall, a name, a pillar, or a post—these trifles seem to bring back to you what you imagined you had lost altogether in the way of direction and recognition of a little known but once traversed pathway. And, of course, you can educate yourself up to this faculty as Robert Houdin and his son educated themselves to recognise at a glance, and immediately afterwards to describe, all the varied objects they saw in a shop window. You travel once along a railway, and you look listlessly out of the window. Your eye sees many and varied objects past which the train hurries you at sixty miles an hour.

Travel again by the same route a month or two afterward, and if your faculty for locality is developed at all, things will not be quite so unfamiliar to you as before—that stunted tree, or that pretty cottage-window with its flowers, or that queer tower, or the signal set high up on the cutting, these things begin to wear a familiar look; and when you come again you find you have got quite a set of landmarks all unconsciously tabulated and arranged in your brain. But it is all different with your cat or your dog carried in his basket, and let out a hundred miles or more, it may be, from his old home, to which he finds his way back, footsore and weary, in a marvellously short space of time. Here, there has been no previous experience I repeat; it is even more wonderful, to my way of thinking, than the manner in which the carrier-pigeon guides its long flight after its training in short flights and essays in the air.

Man here is on a different platform entirely from the animal: and I would say even savage man has advantages over the dog and cat that make his direction-finding less wonderful than theirs. Your Indian knows "a' the airts," and can tell at a glance by the signs of the sun's action on tree bark, for example, whether he is going north or south, east or west. He has a thousand little signs to rely upon in virtue of the trained intelligence that makes him the wary, wily son of the forest he is. But our cats and our dogs, do not know east from west, and yet they come home to us from afar, with that patient fidelity and hungering fondness for a sight of their own, than which there is nothing more touching in all the universe of life or mind.

CHAPTER XV

Mushroom Lore

The fungi and their place in the plant-world—Spores and their history—The development of the mushroom—Fungi as foods—Some views concerning mushroom-propagation.

MUSHROOMS, toad-stools, and the whole tribe of lower plants, to which we apply the general name of *fungi*, exhibit phases of life very different from those we are accustomed to see illustrated in higher or green-possessing plants. The mushroom classes approach animals in respect of their food and feeding much more closely than do ordinary plants. They live on decaying organic matter—some of them, indeed, live as parasites on living beings; witness the microscopic fungi that cause ringworm and many other skin diseases. While a green plant, by day at least, absorbs carbonic acid gas and gives off oxygen, our fungi persistently, like animals, demand oxygen and emit carbonic acid.

It is instructive, therefore, to note once again, that, groundlings as they are, the mushrooms and their allies are in reality much nearer the world of animal life than plants of higher pretensions. It would almost seem as though the fungi represented a kind of passage-way or transition from the plant kingdom to lower animals; just indeed as we might imagine the two main divisions of the tree of living nature branching off low down in the stem. Be that as it may, the host of lower plants presents, even to the popular view of things, many remarkable and interesting features for study. To begin with, our mushroom is a very different plant, regarded from a commonplace point of view, from other and familiar members of the vegetable kingdom. There is no distinct root, just as a stem is also wanting; the so-called root and stalk of a mushroom being very different in nature from the roots and stems of familiar plants. The mushroom fixes itself in the soil by a number of delicate fibres which form what botanists call the *mycelium*, and what gardeners term the "spawn." In its earliest infancy, this spawn represents the whole mushroom; and when its nature is examined we find that the spawn, in place of being a root or anything resembling that structure, is really a collection of vegetating and spreading *spores*.

Now a *spore* is the name applied to the young stage of lower plants at large. It is not a seed, because it presents none of the characters of that body, and because, while it is not developed as a seed is produced, it does not, like a seed, grow up directly into the form and likeness of the plant which gave it birth. We speak of the spores of disease-germs—which, by the way, are low forms of fungi in all probability—and we see in the development of germs, certain phases that unmistakably resemble those observed in mushroom-growth. The spores of germs are notably much more difficult to destroy and kill than are the adult germs themselves. Thus the spores of the germ of consumption resist solutions of disinfectants of a strength more than sufficient to kill the adult germs. It would seem as if in the whole race of fungi, the spores were endowed with a vitality of tremendous strength, as befits the nature of the particles on whose successful survival the propagation of the race depends.

The microscopic spores, then, given off from a mushroom which has reached its flowering epoch develop into the creeping threads that constitute the spawn. From this structure, arise the stem or stalk, and its cap, which is named the *pileus*. On the under side of the cap, as everybody knows, there are to be found a large number of thin plates, set with their flat surfaces closely applied together, these plates being known as the mushroom's *gills*. When a mushroom begins its growth from the spawn, which consists of a set of branching and intertwining threads, we notice that here and there the threads appear to be more closely aggregated and massed than elsewhere. These massed threads are in reality the centres of the mushroom growth to come. Soon little globular projections become visible in the mass of the spawn, while below these other swellings may also be detected.

Later instruction enables us to see that the swellings are the stalks and caps of future mushrooms, and as they grow upwards through the earth the swellings develop lengthwise, and the gills that are to be become marked out by dark-coloured spots placed near the top of the growth. The young plant at this stage is covered by a kind of skin, and this membrane, when the cup is formed, covers in the gills, and is named the "veil." When later growth occurs and the cap expands this veil is naturally separated and torn so as to leave the gills exposed; and we may see the remains of the veil for a time as a kind of collar around the mushroom's stalk.

There is one point of interest in connection with the structure of the full-grown mushroom we have thus traced in its development, which forms an important constitutional difference between the fungus tribe and higher plants, from the fern upwards. This is the fact that, as everyone knows, fungi are soft-bodied things, and possess no hard parts or fibres, such as we see in other plants, and such as are well represented in the veins of leaves or in the wood itself. Our mushrooms and their allies are built up entirely of microscopic cells, and hence they are known as *cellular plants*. Some of the fungi—for example, the yeast plant—consist each of a single microscopic cell; others, like the mushroom, are merely collections of cells. When, also, we consider that the spore of a fungus is itself only a cell peculiarly modified for purposes of reproduction, we can form an idea of the importance of the cell-unit as represented in the whole tribe of plants.

There is one special surface in the mushroom, as we have seen, which bears the spores, and this is the gill-surface. Technically, this surface spread on the gills, is called the *hymenium*, and on the delicate membrane in question the spores are developed. Curiously enough, the spore-bearing surface exhibits plaitings and foldings not unlike those we see in a fan, and in this way a very much larger surface is presented for the important duty of developing the reproductive elements of the plant. It would seem that the spores grow in groups of fours, and each is supported on a delicate stalk, which in its turn arises from a much thicker base. In addition to the spores proper, a close examination of the mushroom's anatomy shows us that certain other bodies which do not bear spores grow alongside the stalks already named. By most botanists these last bodies, which are somewhat swollen and globular in shape, are believed to be sterile or useless spore-bearing stalks.

It would be out of place, at present, to say anything further of mushroom development, more especially as the processes whereby the fungi propagate themselves other than these described can hardly be regarded as having been satisfactorily determined in all their details. But certain matters connected with the diffusion of fungi have attracted scientific notice, and to these facts it will be interesting briefly to refer. A writer, speaking of the colours of fungi, remarks that such attractive hues must be useful to the race. This is a very just observation. With fungi, colours must possess a purpose and function, just as with the flowers of higher plants. There is no lack of colour among fungi. From the pale hue of the mushrooms to the yellow of the toadstools onwards, we find red, orange, scarlet, crimson, blue, dark green, and even black.

Nor is it on colour alone that the mushroom races depend for attractiveness. Some glow with a phosphorescent light, a fact seen alike in coal mines and in tropical jungles. Just as flowers which are not specially attractive in respect of colour usually exhibit a strong development of odour, so we find certain fungi making themselves conspicuous, and sometimes even disagreeable by the emanations which they give off. One agaric smells like fresh meat, and some attract flies and other insects by the veritable carrion stench they emit. The tastes or flavours of fungi are often equally distinctive. Ardent lovers of the fungi are given to boast that there is scarcely a delicacy to be found in other classes of foods which they cannot parallel among their beloved agarics and allied forms of the fungus race. One has the flavour of oysters; another imparts the taste of apricots; and others, again, give the impression of a nutty constitution. Clearly the fungi, possessing such characters, must find for them a use and purpose. It is equally certain that the purpose in question must be connected with the welfare (which practically means the efficient growth and reproduction) of the plants.

The history of the common mushroom, perhaps, illustrates as typically as any other phase of fungus development, the meaning of the attractiveness of the race. It is notable, remarks the writer to whom allusion has already been made, that sheep and oxen are fond of mushrooms. Now, assuming what is probable, that the mushroom passes the first and early stages of its life as a kind of parasite within the body of an animal, just as its adult life is passed amid the decaying animal matter of the mushroom-bed, we may, it is urged, see in the attractiveness of the plant and of fungi at large the means of inducing animals to swallow them. Presuming that we cannot (as it is alleged is impossible) raise a mushroom from its own ripe spores by sowing them in a bed, we gain from this fact the hint that we have not complied with Nature's laws, and that to get our mushroom "spawn" we must obtain it from the proper quarter—namely, the animal body. In the body of the sheep or ox the mushroom spores have undergone their preliminary stages of development. Passing from the animal's body the spores, already advanced in development, fall into the ground. Amid appropriate soil, they produce the "spawn," and out of the spawn, as we have seen, the adult mushrooms grow.

Dr M. C. Cooke, in criticising the views above detailed, casts doubt on some of the special conclusions of the writer quoted. He says it is doubtful whether horses or sheep or oxen eat mushrooms (our country friends might do well to settle this point by simple observation), but adds that the animals certainly do eat the grass around the places where mushrooms have grown. This view may reconcile the discrepancies in the matter, since if grass be cropped near where mushrooms have grown, it is certain spores may be swallowed by the animals, with the result already described.

What is known of fungi other than the mushrooms encourages us to see a distinct science and use in whatever attractiveness these plants may present. A fungus with a disagreeable stench attracts flies, which drink up the matter contained in the spores. Little doubt exists that the insects act here as intermediary hosts to the spores, although of the exact mode of disposal of the spores by the insects it appears we know nothing. Still, it is not unwarrantable to conceive that, passing from the insects' bodies, these microscopic living particles should leave a wide and favourable diffusion over the earth's surface.

The study of mushrooms and fungi at large—which, as Dr Cooke says, most people simply kick over when they are encountered—is thus shown to be fraught with interest. It is also a subject which may well be studied with valuable results by country dwellers, and its merit is that it demands in reality no great tax upon the mind, by way of acquiring the necessary preliminary knowledge of the race.

CHAPTER XVI

Black Diamonds

Coal and its distribution—Varieties of coal—The microscopic teachings about coal—The coal forest and its history—How coal was made.

AT first sight the contents of a coal-scuttle would not appear to present an attractive topic even for the conscientious scientist. Yet from a piece of coal a very considerable number of side issues diverge into widely removed branches of science. Not only geology, but natural history, physics, and chemistry, have all to be laid under contribution to explain fully and completely what coal is and how it was formed. Roughly regarded, coal is known to be composed of plant materials; but the exact fashion in which these materials were placed and circumstanced so as to give origin to the coal seams of to-day is, it is to be feared, a topic on which not too much light has been cast in so far as the public are concerned. It is this question of the vegetable origin of coal which faces us at the commencement of our researches into the nature of this familiar product of the earth.

George Stephenson long ago said in reply to a questioner that it was the heat and light of the sun, bottled up in the earth for ages, that really drove his engines. The engineer was thus expressing a fact of science in familiar terms. It is true that the energy of the sun stored up in plant tissues is liberated in our fires and furnaces to evolve heat, and to produce all the effects which are due to combustion at large. The operations of plant life largely consist in the building up of carbon in the tissues of vegetables; so that coal in this light is only a kind of impure carbon claiming a near chemical relationship with black lead or charcoal on the one hand, and with the diamond itself on the other.

At a remote period in the world's geological history flourished the coal plants which give us our fuel of to-day. The typical coal or Carboniferous period lies away back in the Primary group of rocks, sandwiched (in point of time and order of formation) betwixt the Old Red Sandstone below and the Permian rocks above. But in later ages of the earth's history coal was also formed, although not to such a typical extent as in the Carboniferous age itself. Wherever collections of vegetable matter were placed under certain conditions, and whatever the age or period in which such conditions operated, there coal was formed. So that, while the coals used in this country, in England and in Ireland, as well as in Belgium and France, Bohemia, Russia, Spain, and elsewhere, are of the Carboniferous age, it would not be safe or correct to assume that the fuel burnt in every quarter of the globe was necessarily derived from the same period. Thus, in India, it is probable that the large coalfields are of much more recent origin than our coal seams at home. But in North America the ordinary Carboniferous coal-measures are well represented, and attain a thickness of 4000 feet in Pennsylvania, and of 8000 feet in Nova Scotia, these rocks including in their extent many important seams of true coal.

The proofs that coal is of vegetable origin are not difficult to find. It may be important, as a practical point in connection with this topic, to note, first of all, that the term "coal" is in itself a very wide one. As a writer has put it, the word "coal" has a commercial rather than a scientific importance. In this light, while commercially, a coal is any carbon-bearing rock that will burn as fuel, scientifically, any "coal" is only one variety of rock included in a very large group or class, the one common character of the class being its vegetable origin. What is called bituminous coal is really a form of our common fuel in which the actual process of mineralising has not proceeded to the extent we see in other coals; the term "bitumen" itself, as most readers know, being applied in a general sense to indicate such diverse substances as asphalt, naphtha, petroleum, and like bodies. Ordinary coals may be divided into three groups, respectively known as pit-coal, *anthracite*, and brown coal or *lignite*.

Naturally, the pit-coal consumed in our houses exhibits many varieties. One and the same seam of coal will also exhibit variations, often of wide nature, at different parts of its extent. It is said that upwards of seventy different kinds of pit-coal are imported into London alone, but we speak familiarly of at least four well-marked varieties. Thus, caking coal fuses together and burns in a compact mass, a quality well seen in the products of the Newcastle seams. Then comes the splint coal of the Scottish fields, which is not readily broken, and which, although difficult to light, yet gives a very clear and lasting fire. The third variety is the cherry or soft coal, found chiefly in Staffordshire. This latter variety easily catches fire, has a white, light ash, leaves but few cinders, and does not cake when it is heated. Finally, the cannel (or candle) coal is found to burn with a clear flame (hence its name), while it crackles in the course of combustion, and so is also called parrot. This latter coal is full of gas, and is largely employed in the manufacture of our common illuminant.

Jet, it may be added, for which Whitby has long been famous, is a variety of cannel coal; and anthracite or "hard" coal, possessing but little gas, burns with a red heat, but gives off little flame or smoke. This coal is often called smokeless coal, and is used in steamships, and in war vessels especially, to which it gives the advantage of concealment as far as smoke is concerned in the presence of an enemy. As might be expected, the chemical examination of coal shows us wide differences as regards the amount of combustible material and of ash or refuse matter contained in the various kinds just enumerated. Thus on an average from 70 to 90 per cent. of carbon is found in coals—lignite or brown coal containing the former proportion, splint coal about 80 per cent., cannel coal about 67 per cent., and anthracite about 91 per cent. The quantity of ash in coals varies from about 2 per cent. to nearly 15; the latter percentage we find in cannel coal. In addition to the bituminous coals, and nearly related to them, are the oil shales, so well represented in different localities in Scotland.

A famous Scottish lawsuit will still be remembered as turning on the question whether or not a particular kind of mineral was coal, this mineral afterwards affording the well-known oils which are in daily process of extraction from our shale-fields at large. Oil shales are therefore now fully recognised as occupying a position between common shale (which is only solidified mud) on the one side, and cannel coal on the other. The source of bituminous matter contained in the oil shales is still doubtful, but there would seem little reason to doubt that this matter has arisen from the decomposition of plants, and possibly also from animal matter in the case of certain of the formations in question.

Perhaps the "peat-moss" may rightly enough be regarded as presenting us with a convenient first stage in the consideration of coal as a plant product. These mosses exhibit a peculiar constitution, since the living plants in a modern moss may be found at the top, while below, for many feet it may be, until we reach the actual soil, we find the decayed vegetable matter we name "peat." As becomes its plant nature, peat is largely composed of carbon, and therefore it burns well as a kind of fuel; but the large amount of ash it contains, together with the water which it holds and its looser texture, render it inferior to coal itself. We thus see in the peat-moss the clear possibility of vegetable matter, after rotting and decomposing, presenting us with at least an approach to a coal-like structure.

Proof of a more exact nature is, however, at our command. Thus, when coal is burnt, the products which pass up the chimney and fall on the hearth are practically the same as those which arise from the combustion of wood. Again, the examination of coal and kindred substances by aid of the microscope reveals to us a very interesting structure. It is possible to grind or rub down coal into very thin and transparent slices, such as admit of microscopic investigation. Roughly speaking, we see in sections of coal thus prepared, yellowish portions scattered through a blackish or brown ground substance. As Huxley remarks, however, if we examine anthracite the yellow matter is seen to exist in the minimum, while the blackish matter comes to the front; whereas in other coals in commoner use, the lighter elements predominate. In such coals we see multitudes of little round bodies, yellowish-brown in hue, embedded in the darker ground layer. The average diameter of these bodies is the $\frac{1}{20}$th of an inch. In reality they are really "flattened bags," and research has shown that they are the spore cases (literally the seed-bags) of the curious plants to which coal owes its origin. This first piece of information teaches us that ordinary coal is largely composed of the spores and spore cases of plants; but it also contains materials which plainly evince a fibrous structure, not at all unlike charcoal in appearance.

This observation proves that the fibrous parts of plants enter also into the composition of coal, and the differences between one coal and another, in truth, are found largely to depend upon the special kind of plant-matters which predominate in each variety. Thus in some coals it is the spore cases of the plants, compressed and carbonised, which form our fuel; in other coals it is largely the branches and leaves of the old plants that have contributed to their formation.

The plant life of the Coal Age was, in its way, very characteristic, but, at the same time, very different from that which is presented to our eyes to-day, in our own, or, indeed, in any other lands. All the plants of the coal epoch are extinct. Among them we rank first of all the *Lepidodendrons* (or scale-trees), which raised their tall, naked, and scaly stems many feet above the ground. At the ends of its branches each tree bore the cones or spikes containing the spore cases. This large tree was, however, only a gigantic moss after all. The small club-mosses of to-day are the living representatives of this old coal tree. Other great trees of the Carboniferous times were the *Sigillaria* and its neighbours, which grew to a height of fifty feet or more, and had fluted stems marked with seal-like scars, denoting the places where the leaves were attached. Then came the *Calamites*, giant reeds, "tall as the masts of pinnaces," as Hugh Miller has it; while Araucarian pines, which grew apparently on the drier parts, fall to be included in the lists of the coal flora. Finally, there was everywhere in the coal forests an abundant undergrowth of ferns. Luxuriant must these latter plants have been in the old Carboniferous days, and many and delicate are the nature-prints of their fronds we meet with in the shales of the coal.

Everyone knows that coal is found in more or less circumscribed parts of the earth called "coal basins," and it is probable that each of such basins represents what was once a swamp or low-lying territory. Again, coal itself is deposited in bands, or "seams," as they are called, which vary greatly in thickness. Each coal seam reposes on a bed of fire-clay, or of shale. Into this under-clay in many cases the actual roots of the coal plants (which occasionally remain fossilised as they grew) are seen to pass, while the stems of these plants run upwards into the shales or sandstones that cover the coal seam above. Now, this arrangement of parts, wherein seams of coal seem to be sandwiched, as it were, between shales and sandstones, gives us a clue to the nature of the process whereby the old forgotten vegetation became converted into coal. Each bed of clay is without doubt the soil on which a coal forest flourished and grew, while it is clear the coal seam itself represents the collection of vegetable matter, chiefly spore cases, cones, leaves, and the like, which accumulated at the foot of the trees, as do like materials in every forest of to-day. In a coal-basin seams of coal lying one above the other are thus separated by intervening sandstones and shales, and according to the view just propounded every seam represents the *debris* of a forest, its thickness corresponding to the duration of the forest itself.

How, it may be asked, may we account in turn for the intervening strata which separate the seams? The reply, geologically speaking, is clear and distinct. During the coal epoch the earth's surface was in a state of subsidence. There is no reason to doubt that, at this time, Central and Western Europe were being depressed. We learn this much even from the formation of the limestones which are of Carboniferous age. As the land-surfaces slowly sank, swamps or lagoons were formed. Mud-flats duly appeared thereon, and on this mud-layer in due season grew the plants of the time. If the subsidence was very slow, or interrupted by long intervals of rest, we can imagine how a thick layer of vegetable matter from forests came to accumulate; just as conversely, with more rapid movement or a less prolonged interval, the layer would be of thin extent. But when the sinking began anew, the swamp and its forest would disappear, the vegetable matter would become covered over with river deposits of mud and sand, and so a fresh surface would arise for a new forest growth.

Clearly then, each coal seam must correspond to one forest's growth, and to the period during which its *debris* was allowed to collect; while, as certainly, the intervening sandstones and shales mark by their relative thickness the interval of time which elapsed between the destruction and sinking of the one forest-surface and the formation of a new soil for the next. The seams vary from a few inches in thickness to that of the giant "Ten Yard Coal" of South Staffordshire; while a shaft has been sunk to a depth of 2151 feet (as at Dunkinfield), passing in its course through thirty coal beds of the aggregate thickness of 105 feet. As regards the items, materials, and time represented in the coal formation, it has been calculated that the thick vegetation of the tropics will give us about fifty tons of carbon to the acre during a period of growth of 100 years. This seems both a large amount and a lengthy period; but each estimate is mere child's play compared with what must have been represented in the old days of the coal. For fifty tons of carbon or coal spread over an acre would not give us a layer half an inch thick.

Principal Sir W. Dawson tells us that one foot of coal equals fifty generations of coal plants; and if we assume, on very moderate grounds indeed, that each generation of plants "took ten years to come to maturity, then each foot-thickness of coal represents 500 years." In one coalfield, again, the beds of coal one above another may show a thickness of fifty or sixty feet, so that the estimate is clear enough, that, for the accumulation of such an amount, we must demand a period of at least 25,000 years. There is no absolute time-measurement in geology, it is true, all our calculations are relative; but it seems impossible, at least, to escape the conclusion that the contents of coal-scuttles represent products, for the formation of which, we require to make very large drafts on the bank presided over by Father Time.

CHAPTER XVII

Mechanisms in Nature and in Art

The representation of human machinery in the chemical world—Devices of animals and their mechanism—Comparison of animal and mechanical powers—Some record performances.

THERE is no denying that in the various expedients of the living nature that surrounds us we may easily find many analogies and parallels to the contrivances wherewith man lightens his toil and aids the work of his life. Thus, to go no further afield than the forceps in the tail of the earwig, we find there a foreshadowing of the big shears of the dockyard. In the burrow which the torpedo, or shipworm, excavates in the piles and timbers of piers, we see a model of the special tunnelling work in which the great Brunel was one of the first to engage. The sting of the wasp suggests the hypodermic syringe of the physician, wherewith by skin-puncture and the injection of "drowsy syrups" he is wont to assuage pain. The list of what one might reasonably call prototypes in animal and plant life of the expedients of man might be indefinitely extended. There is, however, yet another point of view from which the mechanisms of man and of nature may be studied, and that has regard to their relative powers and advantages.

Comparisons here, are not always odious, and the study of the relations which science can elicit as existing between man and nature in this respect has been shown by Mr Jeremiah Head, M.I.C.E., to be fraught with interest and instruction. Mr Head has regarded living nature, including man, from the civil engineer's point of view. What he has elicited from his comparative studies discloses much that is novel and striking. What we call mechanical science "has been built up entirely upon observation and experiment, and the natural laws which have been induced therefore by man." This is a plain declaration on the part of the mechanician to start with, and we shall see its justification as our studies proceed. Man in a primitive state, it is remarked, like wild animals, uses tools or appliances to a very limited extent, and in this respect he resembles wild animals themselves. But, on the other hand, the animal may be taught to use mechanisms provided its training be early begun and carefully carried out.

Mr Head gives as an illustration the case of the donkey which draws water from the deep well at Carisbrooke Castle, Isle of Wight. The arrangement there partakes of the nature of a treadmill. The donkey's movements on the mill cause the bucket to ascend through the winding of a rope. When the bucket or barrel comes up to the mouth of the well, the donkey, watching the rope, slacks a little to allow the barrel to rest on the well parapet, and only when this necessary part of the operation has been performed and the barrel secured by the attendant does the sagacious animal walk off to his stable. Donkey education does not proceed very rapidly, however, since we are told that four years were required for the instruction of the animal in his treadmill avocation. Early training in the donkey, as in the man, is necessary. One may well believe that an adult donkey (like some adult humans) would prove to be utterly outside the bounds of any educational success in this direction at least.

In the action of birds drawing up their drinking water from a reservoir placed below the cage in a miniature bucket, something of a mechanical adjustment of their strength to the task is also seen. The bird pulls up the little chain bit by bit with its bill, holding the chain against slipping after each pull with its foot. The bucket, on coming to the required level, is utilised for drinking, and is then let go. Here the educative effort takes the direction of preventing the slipping of the chain; and this in itself is a very vital and necessary act on the part of the bird. The principle of the wedge is also illustrated by birds in the case of the crows, which, developing a sybaritic liking for oysters, contrive to secure the dainty by waiting for the oyster to unclose its shell, when the bird drops a pebble between the valves, and thus prevents the application of the closure principle. Naturally, however, man soon discovered in the course of his evolution that, aided by mechanical contrivances, he could husband his strength, and extend his resources immeasurably.

Mr Head quaintly remarks that in almost every mechanical appliance we use names derived from our bodily structure. The "jaws" of a vice, the "teeth" of wheels, the "ribs" and "waist" of a ship, the "eye" of the needle and the block, the "claws" of a clutch, and many other examples will occur as illustrative of the analogy in language which indicates the still more forcible analogy of form and construction between the living mechanism and the artificial. It is matter of common physiology that we have numerous examples within the compass of our own bodies of ordinary mechanical expedients. The lever is represented in all its varieties. When we lift the hand to the mouth, when we lift the heel from the ground, or when we bend the back, we are using the lever principle. So it is also with joints. The shoulder is a perfect ball and socket or "universal" joint, and the head and neck illustrate a pivot-joint or movement round a fixed point.

Hinges we get all over the body—in knee, elbow, fingers, and toes. A force-pump we find in our heart, and bellows we see in our lungs. The photographer's camera is tacitly reproduced in our eye, and the piano sounding-board and other parts of that instrument are reflected in our ear. The engineer who lubricates his machinery automatically, has his prototype-arrangement in the manner in which a certain membrane oils our joints, and as far as pulleys go, we find little pads, also lubricated, placed between surfaces where it is desirable (as at the knee) to limit friction. All these things are matters of ordinary physiological knowledge, but they are not the less remarkable on that account. What is less clearly appreciated perhaps, in this matter of mechanical arrangement and comparison, is the relative power possessed by man's own bodily mechanism and that exhibited by the expedients on which, in the shape of machinery, he relies for aid.

It seems, for example, that the ordinary speed of a man walking for several hours is from three to four miles per hour; but cases are recorded in which eight miles an hour have been covered, and an average of 2¾ miles per hour for 141 hours has been attained, as in a race from Berlin to Vienna. Man may run, Mr Head tells us, at a rate which has covered 11½ miles in the hour; he swims at a rate of three miles an hour for 100 yards, or for 22 miles at somewhat over a mile in the hour. He can jump 6 ft. 2¾ in. from the ground, and over a distance of 23 ft. 3 in.; and a cricket ball has been thrown 382½ ft. before it landed. Two miles have been run at the rate of nearly 13 miles per hour, and 100 yards at the rate of over 20 miles per hour. The horse, it is added, does not walk faster than man, nor can it excel him in jumping height or distance.

The galloping horse is, of course, superior to the human, for a mile has been covered in 103 seconds, or at the rate of 35 miles per hour; while a horse has trotted a mile in 124 seconds, or at the rate of 29 miles in the hour. Set on a cycle, let us see what humanity can do to excel its own powers by mechanical aid. Mr Head tells us that a mile has been cycled at the rate of 27·1 miles per hour, 50 miles at 20, and 100 at 16·6 per hour. In other cases 388 miles have been done at the rate of 12·5 per hour, and 900 miles at the rate of 12·43. A comparison of Mr L. Fletcher's cycle performance from Land's End to John o' Groat's (900 miles in 72·4 hours, equal to 12·43 miles per hour) far excels the performance of Count Starkemberg, winner of the race between Vienna and Berlin, a distance of 388 miles, accomplished (on horseback) in 71·33 hours, at a rate of 5·54 miles an hour. The Count rested one hour in twelve; the horse died afterwards. The horse, says Mr Head, had to carry extra weight equal to a sixth of its own weight, while the cyclist carried extra weight equal to a quarter of his own.

The advantage of the cyclist, of course, was on his machine bearing its own weight as well as that of its rider, whereas the horse had to bear itself and its rider on its own legs. In the water, man makes a relatively poor show compared with animal mechanisms constructed for an aquatic existence. Porpoises will keep up with a steamer going at 14 miles per hour, and it seems that man can attain a maximum speed in rowing of 12 miles an hour for about four miles distance. Torpedo-boats and torpedo-catchers are built on lines which imitate the fish. One boat of this kind did an average of 30·16 miles an hour in a trial trip, at six one-mile tests. I believe this speed has been exceeded. The *Campania* and *Lucania*, built for other purposes than the attainment of speed alone of course, attain a maximum of about 26 miles per hour.

Perhaps the question of aërial movement is one which has possessed the greatest attraction for the minds of mechanicians and inventors. Flight requires a specialised construction of body throughout, and man is very far removed from any such significant development. But the mechanics of flying animals are constructed on a very wonderful scale, and excite our admiration, whether regarded from the naturalist's or the engineer's standpoint. The gnat is estimated to have a wing-area equal to about 49 square feet per pound of weight, the swallow 5 square feet, and the Australian crane half a square foot only—yet this latter bird flies well. Supposing a man wished to fly on the scale of the crane's arrangements, he would need (at 12 stones weight) a pair of wings each 14 ft. long by 3 ft. broad, or, as Mr Head puts it, double the area of an ordinary room door, and this estimate does not take into account the weight of the wings themselves. If the question of man's ability to fly be argued from the point of view of his available "horse-power," we get some interesting figures by way of showing the disadvantages under which humanity labours.

A labourer working all day is said to exert on an average ·13 horse-power; and for a very short time a strong man may exert himself to the extent of ·46 horse-power. If a man weighing 168 lb. desired to fly, he would have to sustain a weight of 646 lb. per horse-power exerted, in addition to the weight of his flying apparatus; and Mr Head remarks that no birds support even half that weight per horse-power which they have the power to exert. If locomotion in the air is to become an accomplished fact, the conclusion seems to be that it will have to be worked out through the problems of aërial navigation as distinguished from personal flight. The flying machine is something more than a dream of enthusiastic inventors. Mr Maxim and Professor Langley have been hard at work over the problem in question, while Renard's navigable balloon is, of course, a step towards the solution of that problem.

The questions of a light but effective machine and an equally light and effective motor are bound up intimately with every consideration which affects to discuss movement in the air, and it is precisely in the adjustment of these points that the difficulties of the situation exist. But leaving aërial navigation out of sight altogether, and considering not flight alone, but other details of mechanisms relatively to human needs and wants, it becomes clear that man has succeeded very admirably in strengthening his hands in the matter of his powers. As with his senses, so with his mechanics. Man's senses, here and there, are nothing like so powerful as those of lower animals; taken all round, however, they are well developed. And when, by help of his inventive faculties, man aids his own natural powers, he may not excel this animal or that in its activity, but he contrives on the whole to adapt and adjust himself very admirably to the exigencies and wants of the life he calls his own.

CHAPTER XVIII

Jellyfishes

Jellyfishes and their structure—The "open eyes" and the "hidden eyes"—Senses and sense-organs—The story of development—How the zoophytes and jellyfishes are related.

Now that the warm days of summer are not far distant, the times and seasons of the jellyfishes are at hand. No one who has sojourned even for a few hours at the coast is unfamiliar with these beautiful organisms, but it is perhaps not too much to say that few persons, save those who make it their business or pleasure to dive into natural history lore, are acquainted with the really marvellous history which the jellyfishes present for study. In view of any summer holiday-season, a brief account of these interesting animals may be appropriately dedicated to those who find a delight in knowing something of the history of the living forms which everywhere appeal to our notice. The general appearance of a jellyfish is almost too well known to require description. Its body contains only a few grains' weight of solid matter, the bulk of its substance consisting of water, so that the enterprising farmer who once upon a time insisted on manuring his fields with the jellyfishes which had been cast up in thousands on the beach might in reality have added as efficiently to the fertility of his ground by pouring sea water upon it.

Viewing its body as it swims, a jellyfish presents the form of a bell. From the roof of the bell hangs an appendage which corresponds with the bell's clapper or tongue. At the end of this tongue opens the jellyfish mouth, and the fixed end of the appendage (which is hollow) is continued through the bell-shaped body into a series of radiating canals. These latter open into a circular canal which surrounds the mouth of the bell. The mouth itself is closed by a membrane or "veil," in the middle of which is an opening, so that water can flow in and out of the interior of the bell. Around the margin of the body are set certain organs of sense—to wit, rudimentary eyes and ears; and in this situation also we find the tentacles or feelers. The jellyfish thus described, represents one type, at least, of these animals. Those which have the characters just enumerated were long ago called "naked-eyed Medusæ," in allusion to the fact that their sense organs were prominently displayed in uncovered fashion on the margin of the bell. There are, however, other jellyfishes which disport themselves in the summer seas, and which claim to be noticed here.

Thus we find forms not uncommon around our own coasts which possess a swimming bell (or "umbrella," as it is also named), which pulsate in similar manner through the sea, but which, at the same time, differ from the forms just noted in certain particulars. Long ago Forbes and other naturalists noticed that in this second class of jellyfishes there is no "veil" or membrane closing the mouth of the bell, while the sense organs at its margin are also hidden by folds of the bell. On this account the name of "hidden-eyed Medusæ" was bestowed on the latter forms, and these sense organs (eyes and ears), are, moreover, grouped into one set or series, an eye and an ear existing in each sense-mass. The margin of the bell, again, is seen to be provided with numerous tentacles, and often huge appendages float away from the central mouth borne on its stalk. The large "sea-blubbers" met with in warm seas belong to this latter group, whose stinging powers have also been illustrated on bathers to an extent which makes further acquaintance with these "wonders of the deep" highly undesirable from a popular and practical standpoint.

Different as are these two sets of jellyfishes, they yet possess many features in common. They swim by the alternate expansion and contraction of their bells. Expansion of the bell admits of an inflow of water, which is expelled from the mouth of the bell by its sharp contraction, with the result of sending the jellyfish onwards through the reaction of the expelled fluid on the surrounding water. A strong sheet of muscular tissue lines the bell and provides for its characteristic movements. In these animals we possibly meet with the first well-defined example of a nervous system as we pass from below upwards in the animal series. Nerve-cells and nerve-fibres exist—the former originating, guiding and directing the nervous impulses; the latter conveying them hither and thither through the glassy frame. How precisely jellyfish life regulates its nervous arrangements may be easily illustrated.

There is one species (*Tiaropsis indicans*), measuring about an inch and a half in diameter, whose central mouth moves over unerringly to indicate any part of the bell which has been touched; and the mouth, moreover, will indicate parts which have been successively touched or irritated. The object of this arrangement would seem to be that of apprising the jellyfish of the presence of its prey. It lives upon the minute forms of animal life which people the surface of the sea, and as these are swept into the bell with the sea water, such as touch the jellyfish-body are seized by the mouth in virtue of the nervous warnings it receives. Moreover, as the stinging cells of this jellyfish are plentifully located in the mouth, we may see how the prey is at once seized and paralysed by the active clapper of this living bell. Jellyfish "nervousness" is thus proved to be of highly-developed character, and it becomes the more interesting when we discover that, in their essential nature, the acts of these simple animals reflect those which we discern in the highest rungs of life's ladder.

As for the organs of sense, of which mention has been made, they are admittedly of an elementary nature. The "ears" are pits or sacs, containing fluid and limy particles called *otoliths* or "ear-stones." Fine hairs convey sound impressions to the nerves of these sacs, and the ear-stones doubtless increase the vibrations of the sound waves. It is interesting to discover that in one family of jellyfishes at least the ears are simply modified tentacles or feelers. An organ of touch—"the mother of all the senses" has thus apparently become modified to form an ear. If the coloured specks which we call the "eyes" of the jellyfishes be rightly so named, it is not difficult to assume that the sight-impressions they are capable of receiving must be of a rudimentary kind. These animals, we know, are highly sensitive to light. They disport themselves on the surface of the sea in the sunlight, and in a darkened room will follow a light ray around the vessel in which they are contained. In the darkness they descend in the water, and would thus appear to be sensitive to the broader impressions with which the sense of sight has to deal.

Further than this, in the way of sight, it is not likely our jellyfishes can proceed. Their stinging apparatus consists of certain cells, containing fluid, and having coiled up within the fluid a thread or filament. On the slightest irritation, the cell ruptures and fluid and thread are allowed to escape. The thread is probably a dart and the fluid a poison, since coming in contact (in the case of some species of jellyfishes) with the human integument the result is severe pain associated with inflammation of a more or less persistent type. Some near relations of the jellyfishes, indeed, sting very severely. The Physalia, or "Portuguese man-of-war," a collection of animals which swim on the sea surface in the tropics especially, by aid of a greatly expanded bladder or "float," is greatly feared in this respect by sailors. The smaller jellyfishes do not apparently possess the power of wounding humanity, but the larger species, as already noted, have acquired an evil notoriety for their stinging powers.

The story of the jellyfishes, however, hardly ends with the recital of their differences and their structure. A veritable chapter of zoological romance may be said to be included in what is known of their curious relationships with other forms of animal life. Growing on oyster shells and in like situations may be found tufts of plant-like organisms, which are ordinarily mistaken by the casual observer for seaweeds. They grow (as I have described them in a previous chapter) in the strange likenesses of plants, yet each of these rooted and fixed things—"zoophytes" by naturalists—is really a colony of animals closely related in rank to the jellyfishes themselves. Each colony may number thousands of individuals, all bound together by the closest of co-operative ties, in that each derives its nutrition from the common store it has helped to make.

Each colony, again, arises from an egg which has budded and grown, and when we seek to investigate the nature of the life which crowds the oyster shell, we may discover in some cases that the colony embraces individuals which feed it, others which defend it, and others again which propagate its species.

Now, in many cases the individuals of the zoophyte colony, which are charged with the work of producing eggs, develop a strange and singular form. They grow upon the parent stem first as little buds. By-and-bye these buds become hollowed out, as it were; a central mouth appears in the hollow, tentacles fringe its margin, and finally, as the bud breaks away from its plant-like parent, it is seen disporting itself in the sea as a veritable jellyfish, possessing all the organs and parts we have noted as existing in these animals. This free-swimming jellyfish bud passes away from the parent stock, and lives an independent existence for a time. Then it produces eggs, vanishes when this work has been accomplished, and the eggs are set free into the water. Following the history of these jellyfish eggs, we see each settling down in time. It shows no tendency to beget its like, for it develops into a plant-like structure. This is the foundation of the zoophyte colony. The single form begins to bud, and finally there is once more produced the colony of animals on the oyster shell wherewith this strange life-history began. Clearly, then, certain of the jellyfishes which swarm in our summer seas, so far from being independent animals, are merely the free-swimming "agents in advance" of the zoophyte world. Their personality is fictitious; their appearance delusive; their free-swimming habits merely a temporary concession to a curious line of development. But other threads of the story remain for our unravelling. What the zoophyte shows in the way of jellyfish production, the jellyfishes in turn may show in the matter of zoophyte development. Certain jellyfishes are known to us which in all respects belong strictly to that class of animals.

There is a jellyfish known as *Liriope* common on the southern coasts of America. It glows in the water with "jewel-like brilliancy," and swims freely during all its life stages. When Liriope lays its eggs, each produces a faint resemblance to a member of the plant-like zoophyte colony. In this shape it persists for a while, and feeds while it floats and drifts about at the mercy of the waves. Then, later on, the young Liriope changes its form. The bell-like sphere proper to this jellyfish race appears; the tentacles or feelers come to fringe the margin of the bell; and, finally, the adult jellyfish is developed and leads us back to our starting-point. We note here the faint suggestion of a plant-like stage in this jellyfish history, but nothing more; and Liriope remains a true jellyfish when all is said and done.

Another jellyfish (*Cunocantha*) leads us a step further in our search after the clue to jellyfish development. Now we meet with a typical enough species, the young of which, however, when hatched out, actually find their way into the bell of another species of jellyfish. The young form, in this latter case, is much more plant-like than is that of Liriope. It has a long body, a mouth and feelers, and it inserts this mouth into the very stomach of its jellyfish host and consumes the food, like an idler as it is, which that host is elaborating for its own uses. More than this, the parasite jellyfish thus esconced is able to produce buds like itself; and its host is therefore forced to feed a whole family-circle in place of the single original intruder. Yet the traditions of jellyfish life will continue to assert themselves. Still inhabiting the jellyfish host, the young parasites begin to develop the characteristic "bell" of their kind. When development is completed, they escape into the water as true jellyfishes, each bearing a very large clapper or mouth, which in itself is a remnant of their parasitic stage.

Turning to other jellyfishes of the "hidden-eyed" race, we see their eggs giving rise each to a plant-like form, called the *Hydra-tuba* long ago by Sir John Dalzell. For years it may remain in this stage. Then it lengthens and divides crosswise, and as the edges of the divisions become notched, the whole organism resembles a pile of saucers with the jagged edges set one within the other. This fabric falls to pieces, but each saucer swims away as a true jellyfish, and from a little hydra-tuba not more than an inch in length we know of huge oceanic jellyfishes, measuring 6 or 7 feet in diameter, being developed. Finally, in our ordinary stay-at-home jellyfishes we find none of these singular developments. Each egg becomes a jellyfish pure and simple without any intervening stages of plant-like nature such as have just been described. But beyond the mere recital of facts lies the explanation of them; and it may be asked what these curious details of jellyfish development teach us about the evolution of the race?

A review of the whole facts of the case seems to teach us forcibly enough that our jellyfishes, which develop directly and simply from jellyfish eggs into jellyfishes and nothing else, are the highest, because most evolved, members of the group. To seek and find the most primitive jellyfishes we must select those which are still the free-swimming buds of the plant-like zoophytes. There, the jellyfishes are mere individuals of a plant-like organism. They have no distinct personality, and are mere stages in the development of the colony. Later on, we see them, as has been illustrated, shortening their plant-like stage, sending the zoophyte into the background, and developing an independence both of action and of form. Lastly, we meet with the jellyfishes which have for ever liberated themselves from the zoophyte stock. They have acquired a power of begetting their like. Their eggs develop into jellyfishes directly, and not into zoophytes. They have cut their connection with the animal colonies, and have started an independent existence.

If this is so, we must still see, however, in our free jellyfishes, young or larval animals (as regards the colonies) which have declared an independence. This kind of rise in life is not unknown elsewhere in the animal world; and it is none the less creditable because it is the elevation of a young form to the rank of the adult. Contrariwise, it teaches us that even in lower life, aspiration after better things occasionally meets with its reward.

CHAPTER XIX

Sea-urchins

The sea-hedgehog—Their structure—How the star-fish becomes the urchin or *vice versâ* — The urchin and its movements.

THE spring tides in Largo Bay have been much in evidence for the past week or so, and the big tangle-fronds out beyond the rocks have been periodically left uncovered by the sea. This is always an interesting period for the mind which in these parts can find something else than golf to think about, for the retreat of the sea lays bare a host of things which ordinary tides cover and conceal. The other day the ancient mariner informed me that every big boulder in Largo Bay had been duly christened. Some of these baptismal appellations are worth recording. There are the "Three Sisters," and the "Pepple Wood" Rock, and the "Crampie," the "Ring Rock," and a few other choice designations. Moreover there is a legend in existence that the prosperity of Lower Largo (they say nothing of the Kirktoun at all) depends on the maintaining of these boulders intact. The relation between the preservation of the village and the boulders on the beach is not clear to the ordinary mind, of course; but folklore is not given to find mundane reasons for its beliefs; therefore let Lower Largo rejoice in its "Lucky Minnie" and its "Parten Rock," and rest assured that no sacrilegious summer visitor will lay a desecrating finger on its lares and penates of the beach.

Beyond the last of the boulders you and I can stroll seawards to-day, and embarking in the boat which lies handy at the water's edge, we paddle off into the deeper water beyond. Let the boat drift over the tangle-beds, as idle as the painted ship on that calm sea whereof the Ancient Mariner discoursed. Not a breath of wind stirs the air. The heat in the city must be intense, feeling it almost tropical as we do here to-day. The only cool thing about us is the sea, and very inviting it looks as we peer down into the shallow azure depths over the side of the boat. We are right over the deeper tangles now, and easily see what we have come in search of. Feeding on the fronds of the laminaria you see beautiful ball-like creatures, motionless but for the swaying to and fro of the fronds, moved by the gentle ocean swell as the boughs of trees are swayed by the summer's wind. Here, in the boat, is a child's landing-net. Cautiously, we get it under the tangle frond. Next a dexterous move slips it in beneath the big ball resting on the sea-plant. Another movement detaches the ball from the frond, and, lo! in your net you have landed it, and you pull it on board, a spiny, prickly creature, encased in a hard shell, destitute apparently of any sign of life or vitality beyond sundry movements of the collapsed feet which exist by hundreds on its outer parts.

What you have fished for and caught is the common *Echinus*, otherwise the sea-urchin, or sea hedgehog of the common folk. Before investigating its ways and manners, just look for a moment down into the clear water. The Echinus you have drawn from the deep is, you see, of a purple colour. I do not deny that, as it rests on the fronds of the tangle, it is a conspicuous object. It is less so when it reposes on the sand; and it is still less noticeable when, as you may see in some localities, it lies in a regular hollow which it has scooped out for itself in the rocks. Now, you may remind me that animals usually protect themselves by assimilating the colours of their bodies to that of their surroundings. You recall to mind the case of the flounder on the sand, of the grouse among the heather, and of the changing octopus climbing over the rocks in an aquarium tank. Quite right; though the animal ofttimes emulates the actor's art, and adjusts its hue to that of its environment for obvious purposes of protection and defence. Why then, you ask, does this brilliant purple urchin lie peacefully on the tangle-frond, browsing on the plant as if enemies, for it, were non-existent?

My reply to your question is—Look at the urchin in the boat. Observe its spines, borne in bristling array on its shell. Note also its armour casing, and then say whether you think the hungriest cod-fish that ever swam would have courage to attempt such a swallow? I trow not. Even a very hard-up land beast will not attack a hedgehog, and no more will anything, short of a Port-Jackson shark, perhaps, attempt to tackle a sea-urchin. This shark, I may explain, is a fish with a very peculiar arrangement of teeth. Its teeth are set in its mouth like the paving-stones in the street—I do not mean the streets of Largo, for when its pathways are not paved with cobble-stones resembling petrified kidneys, which give progress on them something of a penitential character, they are not paved at all. I mean the paving-stones of the city thoroughfares, and when the Port-Jackson shark takes anything in hand (or rather into its maw), it simply crunches with its paving-stones anything, however hard or spiny or indigestible it may be. But there are no sharks in Largo Bay, Port-Jackson ones or otherwise. Even the stout elderly ladies can disport themselves in the deep with a sense of security born of confidence in the belief that the bay is free from all noxious things (sea-serpents included) and from anything more ferocious than a crab, which, disturbed in its repose, takes a nip—like a thirsty human at the "Crusoe Inn."

Our Echinus, then, is one of those beasts that do not require protective coloration to aid its existence. It has its spiny shell, and that suffices for its defence. It might be otherwise, I confess, with certain near relations of the urchin. For there is one deep sea form whose shell is flexible. When it first came up in the *Porcupine's* dredges and lay flat and panting on the deck of the ship, my late friend, Dr W. B. Carpenter, said to Sir Wyville Thomson, his co-explorer, "This looks as though you had sat on it!" Our boat drifts on through the still waters, and now let us look at the urchin's configuration and form. What sort of creature is it? you ask. Well, it is a far-off cousin of the star-fish. Let me explain how this may be. Suppose I take a five-rayed star-fish and bend its rays upwards, so that its mouth (placed in the centre of the rays, as you know), is downwards, and the five rays meet at the top. You see I have made the star-fish into a ball. This is my first point.

Now, note something else. The five rays of my star-fish are crowded with the little tube feet wherewith it marches slowly and solemnly, as befits its quiet dignity, over its rocky bed. Suppose next, that you fill in the spaces between the five rays of my doubled-up star-fish, you would then have a complete ball-shaped creature thus formed out of a rayed animal. This is what the sea-urchin represents. It is a star-fish (in one view of things) in a doubled-up state. If you doubt it, glance at the sea-urchin in the boat. Count its rows of tube feet, running from top to bottom of the shell. You find there are five rows; double ones, no doubt, but still five. This exactly corresponds with the metamorphosed star-fish, for in that doubled-up beast you get the five rows of feet also.

Then, again, where is the sea-urchin's mouth? Look below. There it is in the middle of that leathery circlet of skin, with five jaws protruding their tips through the opening; and you see in the star-fish we have transformed, the mouth comes to open below, just as in the urchin. Better still, note something else which I think will strengthen our understanding of the star-fish changed into the urchin. The eyes of the star-fish are placed at the tips of its rays. A very suitable position for eyes, I should say, since poking as it does its rays here and there in advance of its mouth, it can be perpetually on the *qui vive* without the exercise of much or any trouble—though what a star-fish can see with its eyes is more than I profess to explain. Well, if you bend up your star-fish rays, where do you get its eyes? The reply is at the top of the ball where the rays meet. Exactly, and where do you suppose the eyes of the sea-urchin are? In the same situation at the very top of its shell, at the opposite pole to the mouth, and just where you would find the eyes in the doubled-up sea star itself.

Of course, I am not forcing this theory of star-fish and sea-urchin relationship down your throat. It may be that a star-fish is the end, and the sea-urchin the commencement of things. It may be that the star-fish is a spread-out sea-urchin, or a flattened echinus (there are such creatures in existence), or a sea-urchin which has been very much "sat upon" in the trials and triumphs of existence, instead of being a doubled-up star. I care not how it came about, so long as you see the same radiate type in both, or an adaptation of a five-rayed common plan to form equally the sea star and its prickly neighbour. For the rest much remains to be studied in the urchin. Put it into this can of sea water. Note how the hundreds of tube-feet, each with a sucker at its tip, begin to inflate themselves with water, and to extend themselves by way of attaching the echinos to the sides of the can. You see how, by aid of its thousands of feet in the five rows of the shell, the urchin moves about, and how it secures attachment to the tangle-ponds.

Then, by aid of this hand lens, look at the hundreds of little snap-jaws on stalks borne on the urchin's shell. Nobody knows what these little snap-jaws are. Somebody once said they were modified spines, I confess I have never been able to picture to myself the stages by which a spine, which is not alive, could ever be metamorphosed into an active living snap-jaw. Perhaps the snap-jaws are parasites on the shell —who can say? The spines themselves are curious things. Each is fastened to the shell by a ball-and-socket joint, and each is moved by special muscles, so that the defence of the urchin is something more than a mere wooden immovable array of prickles. The star-fish, by the way, has degenerate spines on its back; but it must yield the palm to the urchin in respect of adequate defence. The inside arrangements of the urchin are complete enough. It has a digestive system, and it boasts of a heart and blood-vessels. It has a nerve-cord round its gullet, giving off five big branches to the internal parts—all things go by fives in these beasts.

There are five eyes at the top of the shell, and there are five main water-pipes to supply the feet with the fluid for their distension. Then there is the shell itself. You will find it built up of beautiful plates of lime, in twenty rows—that is ten double rows, five of the doubles having feet and five intervening rows having them not. This is the briefest outline of sea-urchin history. More you can learn for yourself easily. Take the urchin home with you. When it dies preserve it in spirits. Being an abstaining animal, it will only take kindly to alcohol when it has no power even to wink an eye in protest against immersion in the liquor.

And then, when the winter evenings come, and when you are back in the city and want something to do, ferret out the urchin you captured in Largo Bay and anatomise him. Even if you clear out his interior, and dry him and varnish him (or rather his shell), it will serve, perchance, to remind you of some happy days spent on the shore of the Kingdom of Fife.

CHAPTER XX

Some Queer Friendships

Selfishness and friendship—The story of the crocodile and the bird—The Ancients' views—Modern observation—Why the bird befriends the reptile.

THE ways and works of human nature are admittedly quaint and curious. Emotions, aspirations, failings, faults, and follies all constitute an interesting study, especially from the point of view of the philosopher, who, of course, congratulates himself that he has no share in the common weaknesses of mankind. But even philosophers have been found to magnify the excellence of at least one virtue which humanity exemplifies—I mean the great gift of friendship. I suppose that, as a man gets on in years he feels bound, as the result of his experience of life, to subscribe to the motto of the cynic, "Many acquaintances, but few friends." The former increase rapidly, especially when a man has been, or is, a social success; the latter are filtered out, as it were, as time, that tries all things, tries them, and finds them mostly wanting.

Of course I am talking of men friends to men. "Women friends do not exist;" at least so says the cynic, and possibly a long experience here again justifies his words. Whether that be true or not, it is morally certain Platonic love is a very mythical thing when all is said and done, for it either ends in the real and proper kind of affection, or it fades away into nothingness. But these are thoughts by the way. What suggested them was the perusal of an account of certain friendships, associations, call them what we will, among animals which reveal certain rather startling phases of human nature to the uninitiated mind.

Very far down in the scale, indeed, do these animal friendships begin. I do not deny there is some selfish aim, or rather some personal benefaction, to be gained by one or other of the parties concerned; but then the philosophers tell us that selfishness rules the roast of human affairs, and that every good and proper and right thing I do, has a kind of smug satisfaction with myself at the root of it all. If I help a blind man across the street I delay my busy steps, I get splashed with mud, and I may get no thanks for my trouble. The philosophers say I go on my way rejoicing, thinking to myself that I have really done a very kind thing, and that I feel selfishly pleased with myself, and gain great self-satisfaction out of the whole affair, to say nothing at all of the pleasant possibility that many eyes have seen me, and that many voices remarked, "How kind and thoughtful of him to have helped the poor blind!" This may be so; it may all be true, and in lower life selfishness may rule the roast as it does (according to the philosophers) in higher life. All the same, animal friendships are worth studying, if only because of their constant nature. It is not every friendship which is transmitted onwards in the persons of the descendants of the original founders of the amity, yet such is the case with the alliances which we now and then hear of as being chronicled by those who watch Nature with eyes that love her and admire all her works.

Herodotus is, of course, known to everybody as the oldest Greek historian, and his period dates somewhere about 500 years before the Christian era. Aristotle is also a writer of respectable antiquity, and a scientist to boot. Now, away back in these mists of antiquity we find chronicled a somewhat curious tale. Speaking of that respectable reptile the crocodile (respectable, I mean, in point of family history and descent), Herodotus is found to write as follows:—"All other birds and beasts avoid him; but he is at peace with the trochilos, because he receives good from that bird. For when the crocodile leaves the water and gets upon the land, he then opens his jaws, and most usually towards the west. The trochilos then enters his mouth and swallows the leeches (found in the reptile's mouth); and so well pleased is the crocodile with this service that it does no hurt to the bird."

This is a story sufficiently startling to warrant further examination, and such criticism may begin with our discovery that Herodotus is by no means the only writer of note in ancient days who remarked the phenomenon of the bird called trochilos, which seemed as much at home in the crocodile's mouth, picking the leeches out of that cavity, as in hopping about on the land. For, while other writers of respectability in classic times repeat the story, we find it surviving lustily onwards into relatively modern times. For instance, John Leo, otherwise Giovanni Leone, and otherwise Leo Africanus, a travelled person, published a book on Africa somewhere about the year 1556. Leo's story was reproduced by that venerable chronicler Purchas, who seems to have acted as a "literary agent" long before the days when such persons (according to the publishers) fatten and wax gross on the percentage they contrive to extract from the authors of these latter times; and this is how Purchas gives Leo's version of the crocodilian tale: — "As we sayled further, we saw great numbers of crocodiles upon the bankes of the islands in the midst of Nilus, lye basking them in the sunne, with their jawes wide open, whereunto certaine little birds about the bignesse of a thrush entering, came flying forth againe presently after. The occasion whereof was told to me to be this:— The crocodile by reason of their continual devouring beasts and fishes, have certaine pieces of flesh sticking fast between their forked teeth, which flesh being putrified, breedeth a kind of worme wherewith they are cruelly tormented, wherefor the said birds, flying about and seeing the wormes, enter into the crocodile's jaws to satisfy their hunger thereon, but the crocodile, perceiving himself freed from the wormes of his teeth, offereth to shut his mouth, and to devour the little bird that did him so good a turn, but being hindered from his ungrateful attempt by a prickle which groweth on the bird's head, he is constrained to open his jaws and to let her depart."

John Leo, it is clear, did not credit the reptile with the kindly intents attributed to it by Herodotus. The latter remarked that it never hurts the bird; Leo virtually tells us that the crocodile would gladly devour the bird but for the prickle on the bird's head. Now, no such "prickle" exists. What Leo and his contemporaries mistook for the prickle is the crest of the bird, composed of feathers. But there is a clear agreement arrived at, over a lapse of 2000 years or so, between Herodotus and Leo, that the birds do enter the mouth of the crocodile and make their exit therefrom unharmed. The "wormes" of Leo are also, it is clear, the leeches of Herodotus. In 1719, one Paul Lucas is found writing of the same curious story. He describes the bird as of the size of a lapwing, and adds that the birds come out of the mouth of the crocodiles after the reptiles have shut their mouths for a period. Lucas adds that the people told him that the birds adopt this strange measure to "feed themselves on what remains between the animal's teeth by picking them;"

and the idea of the prickle on the top of the bird's head, which is used to torment the crocodile and to compel him to open his mouth, is repeated in this last-named version. So far, these old legends agree in their essential details.

The only real point of divergence is the ultimate motive of the bird's visit. Herodotus says it is to remove the fresh-water leeches from the crocodile's mouth. Leo repeats this notion, for his "wormes," as I have said, correspond to the leeches of the elder writer; but Lucas credits the bird with performing the function of a crocodilian toothpick, and both Leo and Lucas remark on the bird's danger, because they credit it with requiring to use a gentle argument in the shape of the "prickle" on its head before it can escape from its imprisonment in the reptile's mouth. I find in the play of "Vittoria Corombona" (act iv.) Flamineo telling the same tale of the crocodile and the bird as a kind of allegory with a moral attached thereto. The reptile, says Flamineo, "hath a worm" which "breeds i' th' teeth of it, which puts it to extream anguish; a little bird no bigger than a wren, is barber-surgeon to the crocodile; flies into the jaws of it, picks out the worm, and brings present remedy. The fish, glad of ease, but ungrateful to her that did it, that the bird may not talk largely abroad of her for non-payment, closeth her chaps, intending to swallow her, and so put her to perpetual silence. But nature, loathing such ingratitude, hath armed this bird with a quill or prickle on the head-top, which wounds the crocodile in the mouth, forceth her to open her bloody prison, and away flies the pretty tooth-picker from her cruel patient." It is easy to point the moral of this story. Flamineo was evidently addressing " My Lord," who had a mind to suppress awkward reminders of past favours done. In this light, the recital, it is to be hoped, had its due effect upon the ungrateful person to whom Flamineo thus taught a lesson of gratitude.

This is the old story of the crocodile and the bird. There it might have rested, swathed in the swaddling clothes which envelop the legend and the myth, but for the painstaking trouble of Mr J. M. Cook, an account of whose remarkable observations has been published in the *Ibis*, a journal devoted to ornithological science. Mr Cook, accompanied by his brother-in-law, visited Lower Nubia, and observed on a sand-bank near Derr, crocodiles and crocodile birds. These observers determined to watch the movements of the reptiles and birds, and dug a sand-pit on the bank, ensconcing themselves therein about the break of day. At noon, two large crocodiles came out of the water. They went on to the sand-bank, and presently, to all appearance, went to sleep. Several of the crocodile birds soon began to flit about the sleeping reptiles, and then, through their field-glasses, the observers saw one of the birds go deliberately up to a crocodile, apparently asleep. The reptile opened its jaws, in went the bird, and the jaws were closed. In a minute or two the crocodile's mouth opened, the bird came out and went down to the water's edge.

The observers failed to see what the bird did at the margin of the river. Whether it vomited up any of the matters it had taken from the reptilian mouth, or whether it merely drank, remains a mystery. In a few seconds it returned to the crocodile and entered its mouth. Then the mouth opened and the bird made its exit once again. This curious operation was repeated a third time. Mr Cook shot one of the birds. Herodotus called the bird the trochilos; and it seems that ornithologists identified two distinct birds as corresponding with the ancient description. One was the Egyptian plover and the other the spur-winged plover. The bird shot by Mr Cook was the spur-winged plover, which is thus the trochilos of which the ancient Greek historian wrote.

The moral of this story is very clear. That any kind of association which actually permitted a bird to live on such terms of intimacy with a reptile as to allow of its entering and leaving the crocodile's mouth at its own sweet will should have a real existence seemed on the face of matters utterly improbable. The ancient accounts were regarded as legends and nothing more. Yet, here is a modern observer who confirms what the ancients saw and noted, and who places beyond doubt the existence of an animal friendship of very unusual kind. The origin of such association probably began in some chance way. Possibly the real explanation is the action of the bird in picking the parasitic leeches out of the reptile's mouth.

This action grew and crystallised into a habit. Reptile and bird alike benefited from the association, the reptile in being rid of its parasites and the bird in getting food. And so we see there is selfishness even at the root of this animal friendship—call it mutual service if we will— the philosophers will say it is selfishness all the same.

CHAPTER XXI

About Right-handedness

Right-handedness and the brain—Our right brain and our left—The superiority of the left brain—Ambidexterity and its culture.

Why do ordinary mortals use their right hand more frequently than their left? and why is it that the right hand has come to assume a dominance of a very decided kind over its neighbour? are questions which savour of the commonplace. Like many other commonplace inquiries, however, they are much more easily propounded than answered. The setting of problems of the "poser" order may be (and very often is) a kind of work or amusement, in which persons very far removed from wisdom indeed, take part. The replies to such queries are often impossible of discovery, even by wise men, though it is at once the glory and the privilege of science to tackle all things in the way of natural mysteries, and at least to make an honest and straightforward attempt to solve them. Now, this very matter of right-handedness presents a curious attractiveness to almost everybody, and has not escaped the attention of philosophers themselves. Sir Daniel Wilson's researches on the right hand and on left-handedness are well known, while Fechner, Weber, and most recently, perhaps, Professor M. Baldwin, of Princeton University, have devoted much time and labour to it. Even the late Charles Reade, the novelist, found the problem of the right hand fascinating enough to enable him to contribute a series of interesting letters to a London daily on this topic, and on that of ambidexterity as a related subject.

What is it that makes the right hand the willing servant and admirable minister of our will? What gives it alike in the roughest and in the most delicate operations, its supremacy over the apparently equally-endowed left? Provided, as is the latter member, with the same muscles, nerves, and other structures proper to vitality, there must be some more complex reason and cause than is to be found in mere size or build, for the victory of the right over the left. It is not in muscle or bone that we can find aids in solving our difficulties. The conditions of the problem lie much deeper than skin and sinew. They extend to the nervous system, and to the causes which have wrought out the prevailing state of the governing centres of our life and existence. In a study of the nervous system, and still more in a glance at the item of habit and its influence, we may hope to pass within the confines of the question of right-handedness and its genesis as an all-important factor in human existence.

Let us begin by noting the essentially two-sided nature of our brain. It is really a symmetrical organ, capable of being split, theoretically in some parts, but naturally in others of its parts, into two distinct halves. If we deal with the cerebrum or great brain, which fills up two-thirds of our cranium, and which represents in the matter before us the essential part of the brain with which we have to deal, we find its two-sided condition perfectly represented. It is divided into two separate halves. The halves (or lobes) are united below the brain-surface by a cross-bridge, it is true; but they are really separate anatomically, and are equally distinct from the point of view of physiology—which, by the way, concerns itself with their workings and their functions. Now comes a very important point in our considerations. We find that each half of this big brain of ours governs, not its own side of the body, but the opposite side. That is to say, all the elaborate movements in which our right hand is concerned are controlled and governed by the *left* half of our cerebrum or big brain, and *vice versâ.* There is no moral doubt as to this fact, even if it be left an open question whether each half of the brain has any influence at all over its own side of the body. That which stands out paramount as a fact of brain-physiology—nay, as an interesting fact of ordinary life—is the ruling of each half of the body by the *opposite* side of the cerebrum.

Physiology and its handmaiden, Medicine herself, alike testify to this fact. If a man is struck with paralysis on his right side, the physician knows that the lesion which has wrought disaster to the mental and physical life, will be found on the left half of the big brain. Conversely, left-sided paralysis is associated with some injury or disease in the brain's right half, and complete paralysis must therefore affect both halves or lobes of the cerebrum. All this is matter of common and elementary physiology, no doubt; but, like a good many other truths which are plain enough to science, it is one which is by no means clear or patent to everyday folks. Let us note how this fact affects the question of right-handedness. If the left half of our brain is responsible for the regulation of the right side of the body in respect of muscular movements and other things, it is clear that this left brain, as it were, is the real ruler and disposer of our right-handed state. As we are right-handed, we are therefore left-brained. Take it the other way. A left-handed man is one in whom there is a superiority of the *right* side of his brain. For once in a way, the weaker right side of the cerebrum has triumphed over the stronger left half; just as, now and then, a hen-pecked husband does astonish his better-half by an assumption of power for which the lady is by no means prepared.

This explanation of what we may call the mere mechanism of right-handedness does not, of course, lead us to the cause of the condition. We merely see the machinery, as it were in this case, without knowing anything about its genesis or evolution. It is not enough for anybody's satisfaction to say that right-handedness is a condition which depends on the superiority of the left half of the big brain. That is necessary to be understood; but it explains nothing, unless we can get at the exact reasons why the brain's left side has come to dominate the work of the right. It is true that this left-brainedness extends to many other works and acts of life in addition to the mere regulation of muscular acts. Thus we speak with the left-speech-centre in our brain, and the right one only occasionally comes to the front when the left gets disabled. The question of right superiority might be referred to one or other of two principles. Are we to begin with the brain and end with the body, or are we to commence with the body and conclude with the brain?

Suppose it is argued, as Charles Reade argued, that it is very desirable we should become ambidextrous, and that we should be capable of using and employing our left hand equally with the right, how, it may be asked, are we to begin the perchance desirable work of educating our one hand up to know what our other is doing? Are we to begin by perfecting the use of the left hand itself, or are we to trust to the brain as a matter of increased education and will-power? The first proposition is feasible enough. I can quite well understand how by constant usage of the left hand in many operations of life, you may induce useful habits in its muscles which may become perpetuated and fixed as part and parcel of its constitution.

As "practice makes perfection" in other things, so a man may by perseverance train his left hand to do many things which are impossible to another man's left hand. A piano player, a violin player, a 'cello player, an engraver, and a watchmaker may, for example, and do, perform, with the left hand, trained and complex acts which ordinary persons, not musicians or engaged in the trades named, cannot undertake. Or similarly, I may be able to shave myself with my left hand, to the wonderment of Smith, who would probably qualify for admission to the surgical wards of an hospital if he attempted anything of the kind. In these cases it seems to me the first impulses towards left-hand education must really begin in the brain. You "will" to do certain things with your left hand, and the act of willing is a brain-act and an intellectual operation, and your muscles respond to the stimulation of your will. Then comes habit to crystallise into concreteness by repetition, the chance or passing action of the hour.

As the Spencerian theory has it, like the little rills of water that deepen the sand-tracks in which they run, so the nervous currents of our lives deepen their channels and come to select their accustomed grooves in preference to strange and unwonted ways of travel. It is this play of nerve force along nerves to muscles, dominated and directed to the right side of our brain, which is the foundation of all efforts in the way of the higher education of the left hand. In other words, it is our will power, and the "intent to do" which lies at the root of nervous enterprise and muscular advance here, as it underlies all other affairs and actions in our voluntary physical life.

It is impossible to discuss in full the topic of right and left-handedness, because the theme is wide and the side-lights one sees thrown upon it are many and varied. We have to discover, for example, what infant-development has to say to this topic, because the child is father to the man here as elsewhere, in respect of his being nearer his ancestors, by a long way, than the adult. Lower life may also in a measure assist us here in an indirect way, although I quite admit that our chief hopes of solving our difficulties lie, like these moot points themselves, well within the human estate. It does not pay lower life as a rule to give to one side a preference over the other. You could not conceive of flight as in any sense a one-sided act of bird-life. Indeed, the essence of flight is its two-sided equality, and the harmony of action between the two sides of the body. A man in swimming approximates closely to the bird in flying in respect of the harmonious nature of his muscular movements through the water, although I have heard swimmers say that there is often to be observed an unconscious drift towards right-handed superiority, which after all is only natural, considering what man, as a land animal, illustrates and exemplifies in the way of movements.

Some people hold that parrots are left-handed, or rather "footed"—certainly some are—but whether it is a natural and accustomed thing for a parrot to hold its food in its left foot in preference to its right, is an undecided question. Lions on the authority of Livingstone, are said to strike with the left paw; in which case we may assume a superiority of the right brain contrary to that which is the rule of things in man. Chimpanzees have been said to be habitually left-handed. As "poor relations" of our own, this fact is interesting, if only by reason of the human divergence from the Simian style. It is clear, however, that we have only touched on the borders of a big subject (in the nervous way) when we have annotated these few thoughts on the right-handed state. That which remains for my next chapter, is to collate the experience and evidence which science brings to bear upon the matter with a view to gaining some idea of the manner in which the right-handed supremacy came to the front in human life.

Meanwhile, we may note that left-handedness has occasionally been shown to possess its disadvantages. A Mr Bligh of Deptford was shot in 1806. Sir Astley Cooper declared from the position of the body and wound the shot must have been fired by a left-handed man. Mr Patch, a friend of

Bligh's, was suspected; but Mr Patch at the same time, bore a very high character and reputation. At the inquest, however, he was sworn, and in the act of swearing lifted his *left* hand. Patch was hanged.

CHAPTER XXII

The Might of "Right"

Right-handedness in ancient times—Some modern statistics—The story of a little child and its hands—Speech and the right hand.

ONE returns to the question of right-handedness with a little clearer insight into the mechanism which rules it after hearing the story of the superior left half of the large brain, governing and controlling the opposite (right) side of the body. But this is only mechanism after all, and not causation. To say that as we are left-brained we are naturally right-handed is to declare a simple fact, which helps us a little, but not very far on our way. That the left hand has had its own chance in the far back past of protesting against the might of "right" is more than probable. Your left-handed men and women of to-day represent this protest in a very practical shape. If exceptions prove the rule, they also often indicate what was the state of matters before the rule became all powerful.

If, for example, you find the horse of to-day to be a one-toed beast all round, this represents the rule of equine development, it is true; but when you find an exceptional horse born with not one, but three toes, this latter phenomenon points to a time before the one-toed state and rule became universal for the horse species, and when the horse species rejoiced in the possession of three digits on each foot. So is it with your left-handed folks. They may represent a period in human history when ambidexterity was the rule, and before right had asserted its might over left. At the very least, it is much more reasonable to conclude that right-handedness is an acquired condition than to believe that from the first humanity, in all its strugglings upwards to "the light of things," has had a preference for using the right hand over the left.

Our gropings in the dark seeking for a possible explanation of the right hand's superiority are relieved here and there by a ray of light from the experimental side as we shall see; but ancient history teaches us that ambidexterity was about as notable a feature of life in the past as it is to-day. There is a passage often quoted from Judges iii. 15, relative to "Ehud, the son of Gera, a Benjamite, a man left-handed;" and the story of how this person slew the fat king of Moab, Eglon, with a left-handed stroke of the dagger which he carried on his right thigh, is familiar to all Biblical students. Again, in Judges xx. 16, it is related there were 700 chosen men left-handed; and of these "everyone could sling stones at an hair-breadth, and not miss." In Homer, also, we have a reference to the wounding of Achilles by Asteropæus, who discharged two darts simultaneously:—

> "At once Asteropæus discharged each lance,
> For both his dexterous hands the lance could wield."

The "cunning" of the right hand is also alluded to in Scripture; and in 1st Chronicles xii. 2, there is an allusion to the "mighty men, helpers of the war," who "could use both the right hand and the left in hurling stones and shooting arrows out of a bow." Thus the right predominance has been a thing of very ancient origin indeed; and left-handedness among the ancients was apparently regarded as being a notable feature, very much in the same degree in which attention is commonly drawn to its occurrence in our own day.

One theory of this right-handed evolution was broached by the late Charles Reade. He believed that the might of "right" arose from the arbitrary selection of the right hand of children by mothers and nurses in teaching them how to employ their arms. Even if this were true, it leaves unexplained not only why the right side was preferred to the left, but it leaves also, and still more unfortunately, out of sight the superiority of the brain on its left side as the governing centre of the right hand. So also, some theorists have attributed right-handedness to the manner in which the child is carried, the right hand being freer, and therefore more liable to be used and exercised.

This view of things finds no great support in actual fact when all is said and done. It is not proved at all that a child's one side is really more confined in its mother's arms than the other; nor is it suggested that the children carried by left-handed nurses, who might be supposed to reverse the natural order of things and rest the child on the right arm (leaving the left arm of the child free) develop superior left-handed powers. I suspect that just as a young infant uses its hands very much as an adult ape uses them in grasping, or just as its big toe is infinitely more flexible than that digit in the adult, so it will use both hands equally in the preliminary movements and graspings of its little life. The adult peculiarities of muscle and brain develop later, but they are all potentially present in the infant nevertheless. The tendency to development is there, and works out its own sweet will, the bias to the right-handed state; so that the study of infancy, as regards motherly care, will not help us much. The infancy of the species and not of the individual might help us to solve our problem, if solution is to come from the study of human development at all.

Dr W. W. Ireland, making some researches into left-handedness among imbecile and ordinary children, found in the former about 11 or 12 per cent. to exhibit a left-sided superiority, the proportion of left-handed children in ordinary schools being also about 12 per cent. He noticed, however, that the imbeciles were much more decided in their left-handedness than were normal children; while among the imbecile class there was a proportion, as large as the left-handed set, who used both hands indiscriminately. He concludes, therefore, that if there were no more imbecile children decidedly left-handed "there was a much smaller percentage decidedly right-handed; for while of the normal children 88 per cent. were right-handed, of the imbecile only 72 per cent. were decidedly right-handed." Statistics seem also to show that among insane and criminal people there is a larger proportion of ambidextrous persons than among normal and decent living folks.

A very instructive essay on right-handedness was written by Dr G. Sigerson in 1884. He combats therein at least one idea of the origin of right-handedness, which attributed that condition to the greater blood-supply which is provided for the left side of the brain and for the right arm. Dr Sigerson shows clearly enough that many animals, in which essentially the same arrangement of blood vessels is seen as that which is found in man, do not exhibit any right-sided predominance. And when we come to the question of the twist of the spine to the right side (which, by the way, is said to be to the left side in left-handed persons) we are once again facing a double difficulty. This twist, to which is attributed the right hand's might, so far from being in itself any explanation of right-handedness, may actually be the result and not the cause of the greater use of the right hand.

Experimental evidence, however, which is man's best method of interrogating Nature, has been supplied of late days by Mr M. Baldwin, Professor of Experimental Psychology in Princeton University, U.S. His subject was one of his children, and the period of experimentation extended from the fifth to the ninth month in her life. This child was never carried about in the arms at all, was never soothed to sleep or when crying by being walked about in the nurse's arms; was not allowed to balance herself on her feet, and was frequently turned over in her sleep. The conditions for determining such phases of life and developments as might throw a light on the preference for the right hand over the left was therefore very carefully and typically represented in the case of the professor's offspring.

The experiments included reaching for coloured objects, and for other things placed at varying distances, and in unsymmetrical situations. In the course of 714 experiments the right hand was used 173 times, and the left 166 times; and both hands 405 times. The total of 2187 experiments, inclusive of that just named, gave a use of the right hand 577 times, of the left 568, and of both hands 1042 times. Here, then, was illustrated no preference for right or left. Under an experiment involving 80 trials, in which the child had to strain to reach an object, the right hand was used 74 times, the left 5 times, and both hands once. These trials, judged as to the distance reached, gave, at 12 inches, 29 times for the right hand, 5 for the left, and 1 for both hands; at 13, 14, and 15 inches the right hand alone was used. It was employed, at these latter distances, 10, 33, and 2 times respectively. Here there was a marked superiority—a tendency exhibited in right-handedness as compared with the trials first recorded. The effect of straining to reach an object evidently meant a great deal in determining the right-handed inclination.

When there was deviation to the left hand of an object to be grasped, the right hand was similarly called on, and the left hand fell into disuse; so that it is clear the left hand was not utilised to grasp the article placed nearest itself. With colours the result was similar; the stronger effect, as Mr Baldwin puts it, resulted in a preferential choice for the right hand. This preference goes hand in hand (in the child) with the stimulus to exertion derived from the selective power of the eye. It was evident that right-handedness here had developed under pressure of muscular exertion in the sixth and seventh months of the child's life. All this time the child had not learned to stand erect; so that the idea of the body-weight, relatively to the one side of the body, as affecting right-handedness, cannot be taken into account as a factor in determining the child's preference. Speech was absent, of course, so that right-handedness develops apparently prior to the articulate powers. One other point in Mr Baldwin's experiences with his child is worth noting. Where the one hand was used in preference to the other, "the second or backward hand followed slowly upon the lead of the first." If this latter fact has any meaning at all, it indicates that probably the ambidextrous condition was our original state. The slow following of the second hand is a faint survival of the once universal and common power to employ both hands equally for all purposes.

It is clear, then, that right-handedness is a state the origin of which must be sought in deeper circles and conditions than pertain to the shallows of mere bodily conformation. That which seems specially to distinguish man from lower animals (apart from his general intellectuality) is the power of speech. Now, can we find in this fact a possible clue to the origin of the right-handed state? The speech-centre in man is situated on the more active left half of the brain. We habitually speak with the left speech-centre, just as we habitually use our left brain centres for the many duties which the right arm performs over the left. It is true we have a right speech-centre, but this remains in abeyance—a fact proved by investigations on the brains of those who have died while suffering from *aphasia* or speechlessness, an ailment which is accompanied, as a rule, by destruction of the left speech-centre.

A very notable fact comes into full recognition when we are reminded that the centres which govern the movements of the right arm are situated close by the speech-centre of the left half of the brain. Is it therefore at all an unlikely view of things that the superiority of the right side of our body has grown up *pari passu*, as a human speciality, with the evolution of speech? The left brain, which became the stronger intellectually in an articulating sense, would naturally come to exhibit a preponderance of power in its other centres, so that the muscular movements of the right arm would thus tend to be developed largely and permanently over the movements of the left. As regards the legs, they stand physiologically on a different footing from the arms. The latter are many-functioned parts, while the legs cannot boast of much specialisation of their duties in any sense of the term.

It is perfectly conceivable besides, as has been pointed out, that we may get a harmony of action of a very decided kind between brain functions that seem of very remotely-related kind. The very gestures which are used to indicate our emotions, and which therefore represent speech in signs, illustrate a relationship which may not be without its due weight in considering this possible origin of the might of "right." The "hand eloquent" is thus seen to be a natural result of that harmony between the right side of the body and the function of speech. In itself the gesture-speech of our right hand, from this point of view, is only a further development of our right-sidedness all round. You only want a beginning; and when that which has begun is of advantage to the race, you speedily find nature taking means to perpetuate the useful variation.

This is evolution again, in a nut-shell, however we may work out the idea as applicable to special cases. Right-handedness, regarded as I have indicated, is really the gift of speech, which, like a certain virtue, once attained, is found to carry in its train a whole abundance of other goodly things.

CHAPTER XXIII

About Flies

The plague of flies—The fly and its curious development—The fly's tongue and some of its depredations.

SUMMER is here, and we rejoice in many blessings in the way of weather. But there is never a rose without its thorn, and with the summer come the days when all nature perspires, and bemoans the heat of the days and the stuffiness of the nights. Then we indulge in our usual growl over the unsuitability of the tall hat and the black coat for summer wear, while nobody has courage to inaugurate anything in the way of cooler and more rational costume.

The summer days bring other trials in their wake, and among them the fly. Fine weather may fail us, holidaying may go wrong, the little schemes of mice and men may "gang agley," the big cabbage and the preternaturally developed gooseberry may remain within normal limits, and even the sea-serpent may rest within the abysses of the sea—but the fly, like charity, "never faileth." The advance guard comes on ahead of the main body, as becomes its nature. A solitary fly appears, as if to remark, "Here we are again!" and then the great fly army comes in sight.

If ever a natural history calendar is to be constructed, I have at least one suggestion or two ready for the maker thereof. One date not very far off, should run, "The fly appears;" another will bear the legend, "Fly-papers are ready;" a third (later on) might advise us, "Let not flies sully your temper *à la* the ointment of the apothecary;" a fourth (still later), "Look out for the decay of the fly-season;" and a fifth, "The fly has gone." Gone! but whither? That is exactly what no man, or woman either, seems precisely to know. What we all know is that the fly will reappear next season with the undeviating punctuality of the gas collector or the income-tax schedule. Like small boys, the power of the fly to worry and annoy us stands in inverse ratio to its size. Of all the plagues which vexed the Egyptian people—and there are certain which were undoubtedly grievous enough—I think I should give my casting vote in favour of the worries of the fly.

Where the flies come from is a point we may as well try to settle—I use this word advisedly—before we proceed to unravel fly history further. I have said nobody exactly knows what becomes of them, but this is obviously incorrect, taking my statement literally. Many die a natural death apart from medical treatment; many (thank heaven!) are poisoned by the seductiveness of the fly-paper, though what a fly can see or taste that is nice in the unattractive *papier moure* passes human comprehension to discover. Some meet their fate by drowning in the cream-jug and elsewhere; others are slain and die a violent death, being slaughtered by towels and dusters and similar lethal weapons.

But these events do not appreciably affect the great army which buzzes around us everywhere, and it is the case of the last fly of summer which affects the zoologist. What becomes of this last fly and his neighbours? Some say they retire to crannies and crevices, and, like the bears and bats, hibernate all winter in a half-dead and dozing condition, to wake up in the early summer, and to lay the foundations of the new races which carry on the warfare of the fly season. I have even read of belated flies being thus found in dark places clinging in a dormant state to walls, literally unable to stir hand or foot till the reviving warmth should call forth their vital activity once again. If, however, we do not know much about fly life on the quiet, we know something about that life in its early stages, and that something is interesting enough in its way.

The fly, like the butterfly and the beetle, is an insect which undergoes a perfect metamorphosis; in other words, it begins life as a grub or caterpillar; it has a chrysalis or resting stage, and it emerges from that stage as the perfect insect. Doubtless the eggs are laid in decomposing matter, for the fly has low tastes in this direction, and the legless larvæ or caterpillars which are hatched out from the eggs are smooth shining bodies, fleshy, and yellowish-white in colour, and in length about four lines. These larvæ are rapacious enough, though they fall behind the caterpillars of the bluebottle and other flies in this respect.

Then comes the pupa or chrysalis stage, in which the house-fly is said to remain for a period varying from eight to fourteen days. Now, in the fly's development some curious phases occur. When the legless larva leaves the egg, there are found inside its body certain masses of its substance to which science has given the name of "imaginal discs." These are rounded masses of tissue, the use and purport of which were for long unknown; and there are twelve of these masses situated in the chest region of the fly-larva, whilst others exist in the front region of the body. No change happens to the discs so long as the fly remains in the larval stage. When, however, the larva, enclosing itself in its hardened skin, becomes the resting chrysalis, a wonderful activity prevails within the apparently quiescent body. Each of these masses enlarges, and seems to be charged with the duty of supplying the materials out of which the body of the future fly is to be built up.

Thus we find some of the discs become converted into legs, and into parts of the body-joints of the fly, and others give rise to its head and the appendages of that region. While this process of building up the future fly is going on, the organs which did duty in the larval body are being disintegrated and broken down. Having served their term of office, as it were, they disappear, and fly-existence knows them no more. It is only the tail of the larval fly which survives the wreck of the caterpillar stage, and this appendage is transformed into the tail of the full-grown insect. There may not be much of romance in our fly's history, but I am inclined to think, whatever of that quality does exist, may be held to be best represented in the wonderful nature of the transformations whereby the grub becomes metamorphosed into the perfect creature.

No one denies that the fly is always eating and gormandising. Whether it is sugar or cream, or bread or honey, or other comestible, the fly's appetite always appears to be the antipodes of delicate. There are certain insects, *yclept* day-flies, which are not true flies at all, of course, and which are born in the morning and die before night. Hence their scientific name of *Ephemeridæ*. Now these flies, whatever they may do in their larval state, do not feed at all in the adult condition, and, indeed, they have practically no mouth-parts to feed with. It is a thousand pities our familiar—I should say our obstinately familiar — fly is not in the same position in regard to appetite and the term and span of its existence. But it is of no avail to speculate on the "might have beens" of life; and what we do know is, that if Providence has not been kind to the day-flies, it has been bountiful to the household pest in the matter of mouth-parts.

Before me lies a volume of Ruskin, a choice book, bound in morocco. Last summer this volume lay a while on a table, where, by the way, no books that one has any respect for should be allowed to lie at all. The flies evidently conceived a violent admiration for the apostle of culture, or at least for as much of him as was represented by the binding of his book. To-day, that binding is scratched and defaced in a manner which is positively disgraceful. It is rasped literally all over, and my Ruskin is spoiled, from an external point of view at least. The flies accomplished their wicked work by aid of their tongues. As in higher life, that portion of their anatomy is an instrument of evil. If you place the tongue of a fly under the microscope, you will see the nefarious tool which scratched my book.

You may even see the fly's tongue without a microscope at all, if you watch him, or her, alighting on your sugar; for they say the female population (as in higher life) predominates, although science has not yet settled the question of the relative length of tongue in the two sexes of flies, as certain impudent human males have settled it concerning their female relatives. When the fly swoops down on the sugar, you see him unbend or unfold from the under side of his head a something which really looks like a jointed leg. This is the tongue. Then, when it is extended, two flat fan-like leaves open out at its tip. These are armed with suckers and sharp file-like processes; so that whether it is a liquid or a solid refection which the fly has condescended to taste matters not. This is natural enough; but when the same file-like tongue is rasped over the boards of my Ruskin, or over the polished surfaces of furniture and *articles de luxe*, then is the time to complain.

Yet all you may do is to use strong language, and to rush to the chemists for a further supply of the poison-paper that lures the insect to his fate. You may well be forgiven if you hope (*pace* Miss Cobbe and her friends) that when the fly does get a more than tonic dose of arsenic from the paper (arsenic is said, in appropriate doses, of course, to be an admirable tonic), it may be made to squirm, in revenge for the destruction and annoyance it has caused.

CHAPTER XXIV

Primroses In

Primroses and their neighbours—"Pin-eyed" and "Thrum-eyed" flowers—The meaning of the flower—Fertilisation, self and cross—How cross fertilisation favours evolution.

PRIMROSES are in, and the world is all the better and the brighter for their coming. To-day I sat on the railway bridge while waiting for my train, and regarded the cutting beyond, radiant with its show of blossoms. The children had just left school, a charming rural seminary in a lane fragrant with flowers; such an institution as well might cause even a School Board to cease from troubling, or a Government Inspector to take his rest. I heard the children's voices repeating their lesson as I walked to the station, and the sound itself was drowsy and seemed far-off and distant, as some things will do when you yourself are verging on dreamland. Posies of primroses were set on the windows of the schoolhouse, gathered, I doubt not, by little fingers that execute a labour of love in bringing teacher flowers to make glad her heart. Even the porter at the station, albeit he is a staunch and uncompromising Radical in politics (although very much afraid of his wife in private, as is not unusual with men of pronounced opinions abroad), has bedizened himself with the flower that Primrose Dames and others of that way of thinking revere as the symbol of their creed.

It is primrose-land all around me, for cowslips abound in the field, and your cowslip is but a primrose itself. It is, in truth, a near relative of the *Primula vulgaris*, which is the scientific Christian name and surname of the primrose plant. The cowslip's name is *Primula veris*, and there happens to be another well-known relative of these two—the Bardfield oxlip (*Primula elatior*). Linnæus of old, so Darwin tells us, regarded the three as mere varieties of one species. Darwin took the opposite view. He thought they were as distinct and separate in individuality as, say, Brown, Jones, and Robinson, or, to put it much more respectfully, as the Horse, the Ass, and the Zebra. That reminds me, however, that the relations of the primrose class are not to be settled by this simple declaration of the threefold identities. There is also the oxlip (the common one, not the Bardfield individual) to be considered.

This is a little left-handed branch of the family, not to put too fine a point upon it; a kind of bar sinister arrangement which shows that little slips and failings for which Dame Nature is responsible, are apt to intrude themselves into domestic arrangements in lower as in higher life. For the oxlip is really a hybrid person when all is said and done. Darwin has traced its pedigree both backwards and forwards. The primroses deny it as a member of their species, and the cowslip rejects it utterly. Between the two, it falls to the ground in respect of its pedigree only, for it is hardy enough, and flourishes perchance where neither of its disdainful relatives might be able to make a living at all.

The oxlip is a hybrid, or half-breed in other words, and represents a cross between a primrose parent and a cowslip progenitor. I said there were frequent slips to be noted on the part of that excellent lady Madre Natura, and this is one of them. A little confusion of parentage, and behold the oxlip; and it seems the primrose family is the more frequent defaulter here as the seed-bearer; for when it is crossed by or with the cowslip, it is more fertile in the matter of seeds than when the reverse feature is seen. This is a little slip really on the part of some stupid moth charged with the conduct of the matrimonial arrangements of the cowslip and primrose family. Instead of fertilizing primrose with primrose pollen, it has sipped the cowslip's sweets, and, dusted with cowslip-pollen has made an alliance by deputy betwixt the two distinct species. But these little accidents will happen, as we know; the great blessing of it all is that they do not occur more frequently and cause much confusion to the modern successors of our first parent, the original gardener.

If you will look at the primroses on the railway bank, and dissect one or two, you may find their study interesting enough. In my hand I have two kinds of primrose, and had you watched me make my selection, you would have noticed that those in my right hand I gathered from one plant, while those in my left were gathered from another and distinct plant altogether. When I say I have two kinds of primroses, I mean rather that I have by me two forms of primrose flowers. Observe the differences between them, for thereby hangs a tale. The village children call them "pin-eyed" and "thrum-eyed," and the little maiden who makes a necklet of the flowers uses one sort in preference to the other, because the tube of the flower is longer, and she can more readily join them in a string. She prefers, therefore, the primroses with the "pin-eyes," and when you tear open the flower, you notice first that the upper part of the seed-producing pistil comes right to the top of the flower. Also you see that the anthers that contain the yellow pollen or fertilizing dust in this pin-eyed flower are placed away down within the flower-tube.

Look at the other flowers. They are the "thrum-eyed" forms, and here note how the anthers are set quite at the top of the flower, while the top of the pistil only reaches half-way up within it. To see the pistil in the thrum-eyed flower, you have to tear it up as you did to see the anthers of the pin-eyed variety. Years and years ago botanists noted these differences in primrose flowers and in others that show like variations in form, but it was left for Charles Darwin's genius not only to open the book for us, but to construe the meaning hidden in its pages. How often does genius show itself in the revelation of the meaning of a plain something that everybody thinks (after the discovery) he should have seen at once.

It is a great gift this, of being able to see the true meaning of a fact. This is where philosophy differs from mere gradgrind learning. You may be stuffed as full of facts as a Strasburg goose is crammed with ill-gotten and inconvenient adipose tissue, and yet you may be only a walking encyclopædia at best, with a head for figures, and a memory for dates, and—well, and for nothing more. But that is not true learning or culture. The philosophy comes in when you have placed your facts in order and relative to each other, and when you make them explain themselves by the very order in which you arrange them. The Board Schools are turning out living encyclopædias every year by the thousand; what percentage of philosophers (in a mild way) do you think the modern educational cramming-mill is likely to produce? And yet it is your philosophers who think about the facts of life, and medicine, and machinery, and even law, who make the old world new, and who increase the sum total of human happiness very largely indeed. This is what Charles Darwin did, working patiently in his garden in Kent. He saw the meaning of "pin-eyed" and "thrum-eyed" cowslips and primroses, and in his explanation of that meaning opened the first page of a history that has served to enchant every mind that loves to regard the face of living nature.

About the end of last century, Sprengel of Spandau managed to catch a glimpse of a great truth about flowers and their fertilization. When you see a buttercup or primrose, or any other ordinary flower with stamens and pistil in each flower, you might reasonably conclude that Dame Nature meant each flower to fertilize itself. Why, otherwise, should you find all the necessary apparatus lodged within each blossom? But Sprengel, looking deeper than his fellows, observed how insects visit plants; he observed their ways and noted also how most plants showed contrivances for actually preventing an apparently desirable end—that of propagating their race through the self-production of seeds. He laid down the law that Nature does not desire any complete flower to be self-fertilized. So far from using its own pollen to produce its own fertilized seeds, it seemed that what Nature aimed at was to get each flower fertilized by pollen from another and different flower of the same, or of a nearly-related species.

This is what you call "cross-fertilization," and there is not a particle of doubt that it is the rule of plant life, while "self-fertilization" is the exception. And to carry out Nature's behests, she sends the pollen sometimes on the wings of the wind; ofttimes she will make the river carry it; now and then, a bird will convey it; but it is the insects which she regards as her chief ministers and servitors in the work. Flower and insect unite their forces to produce the desired end, and when next you see the pine-pollen blown in sulphur clouds by the wind, you will perchance remember my words to-day, as they will be recalled also, I hope, by every primrose you may henceforth see.

Go back to your primrose and see now what happens when the loves of the flowers are represented in our midst, and when floral courtship (like human marriages in June) is at its height. Both cowslip and primrose are insect-fertilized. You might predict as much from a mere glance at these flowers. If you watch the cowslip, you will see the big bees enamoured of its honey stores; for the flowers offer to the insect a free breakfast-table in return for the unconscious service the insect discharges. It is a carrier of pollen; a kind of matrimonial go-between, but it has its reward in the sweets it sips. Nay, more, those sweets are placed on the flower in such a position that the pollen is certain to be taken away by the insect, as it brushes against the anthers in its hurry to taste and be gone. As for your primrose, it is doubtful whether bees affect its society much. The humble bees do not trouble it, and Darwin rarely saw smaller bees visiting it; it is the night-flying moths on which it depends for its cross-fertilization.

The cowslip will also entertain the moths by night, so that its meed of attention appears to be somewhat larger than that which falls to the share of its neighbour-flower. And so you can think of your moth visiting first a pin-eyed primrose. Down goes the tongue of the insect—humanity is not the only long-tongued animal in creation—into the hollow of the flower. You remember where the anthers with their pollen were situated, half-way down within the flower-tube; and thus you note it is the middle of the moth's tongue which will be dusted with pollen. Now withdrawing its tongue, suppose the moth flies off to a "thrum-eyed" flower. Once more it inserts its tongue in search of the honey store; but observe that in this very act, it brings the middle of the tongue, dusted with pollen from the pin-eyed primrose, in contact with the pistil of the thrum-eyed. This is cross-fertilization. You have had the walls of the pin-eyed flower fertilized by the pollen of the other variety. Nor is this all. When it is still drinking its honey store from the thrum-eyed primrose it is getting its tongue dusted with pollen at its base, that is, near its head, from the anthers of the thrum-eyed flower. So when it next visits a pin-eyed primrose, this pollen will be left on the pistil of the latter flower. Cross-fertilization once again, and this time from the thrum-eyed to pin-eyed primrose. It is double fertilization this, and is truly an act wondrous to behold. In your cowslip the bees will effect the same interchange of pollen; and you may safely say that in ninety-nine flowers out of a hundred the same work is being carried on in varied ways and through many contrivances of marvellously complex kind.

This is what Darwin called legitimate fertilization. He was right. It is legitimate because it represents the aim and end after which Mother Nature is striving with all the exercise of her ingenuity to effect. The illegitimate method, which represents one of those little slips of which I have spoken, is seen when any primrose or cowslip uses its own pollen to fertilize its own pistil. This result will occur now and then, accidentally probably, and when it does happen, mark the result. You get more seeds and healthier offspring when you have cross-fertilization than when you attain seeding by any self-fertilizing method. Even if you fertilize your primrose by pollen from the same variety of flower—that is, pin-eyed pollen from one plant, used to fertilize the pistil of another pin-eyed primrose—you will still find you are defective as regards the seeds the plant will bear. Now there lies a deep meaning behind all this anxiety of nature to secure cross-fertilization.

You cannot doubt that some "eternal purpose" runs here as in "the process of the suns." I can tell you what that purpose is. If you get more seeds, you similarly achieve a larger chance of variation among the plants that grow up from them; and variation is the keynote of evolution. For it leads you from small things to greater things, until new species are evolved out of the old. This is the end of cross-fertilization all round. It is the problem of "new blood" being infused into the living races, with all its powers of conferring increased vitality on the children of life. Living things left to themselves wax old and wane; when you begin to strengthen their races with fresh increments of force, you arm them against the perpetual warfare which death and decay wage against everything that is alive.

The story of the primrose is thus a little lesson in evolution for you and for me and for everybody who thinks seriously of his destiny, personal and otherwise. The very train whose steam-clouds I see in the distance, is an expression of what evolution has done for us in one of its many aspects. It is a hopeful gospel this to believe in, nay more, it is a practical one to follow, for its call to duty is that of the Wise Man who reminds us that life is short, and that to-day alone is ours wherein to do the work that awaits hand and brain.

The porter of the primrose-decoration clangs his bell. We part here, perhaps for many days, but the world will move all the same, and bring us, I trust, to our green pastures and quiet havens. Fare you well.

CHAPTER XXV

Holly and Mistletoe

Yule-tide and its plant associations—The holly and its success in life—Mistletoe and parasitism—Degradation in higher and lower life.

It is not typical Christmas weather here; it is, indeed, as mild where I sit to-day as is an April morning. There is an air of auspicious cheerfulness, too, about all manner of feathered things that go hopping about the lawn which betokens that they are enjoying a Green Yule. The "fat kirkyard" that is proverbially declared to be the concomitant of the mild Christmas, will have a full chance of exemplification in the present year of grace, albeit half an hour suffices in this changeable climate of ours to convert May into real December. A big blackbird has been investigating the ways of worm-life with great success for the last hour, and his Christmas dinner would at least seem to be ensured; while there are sundry companions of his that, less intent on things material, chirp out their carols as if in high delight that the sun shines and the frost and snow delay their coming.

Jean has just come in, bearing in her arms a load of holly and mistletoe. It is not Christmas weather, but she argues, strictly to the point for once in her life, that it is Christmas time. Therefore she must needs decorate her home, and repeat in her nineteenth-century life the fashion of the venerable Pagans whose mystic rites may well have been celebrated not a mile away where the dolmen is, and where the big stones that country folk think were "left by the giants" mark the sight of the Druidic sanctuary. Jean is singing something about the desert being a Paradise "if thou wert there." I know who the "thou" is. A tall, broad-shouldered person, who has captured the fancy of the lass, and who will one day take her to a little home of his own which Jean will decorate with holly. When that time comes, the old folk will have to garnish their domain all by themselves, and this is truly sadness to think about, even if it be of the order of things which is inevitable.

As Jean is singing, I am thinking of another scrap of poesy wherein another poet sang the praises of the Paradise of two. This was Omar, beloved of all who love sweet songs.

> ' A book of verses underneath the bough—
> A jug of wine, a loaf of bread, and thou
> Beside me singing in the wilderness—
>   Oh ! wilderness were Paradise enow !"

The dweller in tents struck the keynote of love, and Jean a couple of thousand years thereafter is singing, as Omar sang, of her especial corner of the world wherein dwelleth all good things.

Jean's holly is being distributed with taste around the room, and here and there the mystical white berries of the mistletoe and the lighter green of its leaves make contrast with the darker holly. Why does the holly keep so green? is a question which Jean is asking in the intervals of her song. She thinks of other leaves that fade and wither, and pass away into the nothingness that follows life everywhere into a grim shadow. The lime is stripped, and the horse-chestnut has been derobed of its fan-like leaves, and the oak has but a poor and a vain show to represent its summer beauty. Yet the holly remains: its leaves defy all weathers, and they shine with a resplendence that betokens a successful battle with the conditions of existence. The firs and the pines and others of that ilk, which represent a very old family of trees indeed—a cone-bearing set which may well carry us back to the days of the Coal itself—are also resplendent at this Yuletide season. But their leaves are needles mostly, which gain a fictitious importance because of their number, while the holly leaves are honest things, broad, and each in its way a high development as leaves go.

Jean's inquiry opens up a whole vista of botanical thought. She suggests to one's mind, first of all, that successful struggle with existence which I mentioned a moment gone by. Where other plants have failed to preserve an evergreen character, holly has succeeded. In this dwells wisdom. All success in life means perfect, or at least a fair, adaptation to your environment. When you find yourself in new surroundings quickly adapt yourself to them, lest a worse thing befall you—this is the wisdom of science—nay, it is the wisdom of all time. When you and I get out of touch with our surroundings, we are bound to fail. It is the environment that makes the man and shapes his destiny, and it has in like manner made the holly tree. Through ages of slow variation, always in the direction of gain, the holly has been laying up for itself a store of strength. It has been thickening its leaves to resist the wintry chill. Note how your holly leaf is twice as dense and as thick as most others. It has become impervious to the cold and the frost. Inside its well-protected cells, the processes of holly nutrition proceed equably in winter as in summer. It is like the little fat grey man of the song, who, when the rain his garret floor wets, tucked up snugly in bed forgets the storm. He rises superior to his surroundings and laughs through life, and in a quieter way your holly imitates him. It is not a matter of a day or a year, all this adaptation. Nature now and then takes a flying leap towards bettering her children, but it is on the "line upon line" idea she habitually works. The advantage of slow and continuous adaptation to a particular mode of life is what that holly leaf teaches you and me to-day, and even its red berries are eloquent to the same end of instructing us in the becomings of life.

These berries that gleam red amid the leaves were similarly fashioned that they might shine forth prominently in a season when dull colour is the rule. They present an invitation to our friends the birds. The holly desires that the birds should eat its berries and scatter its seeds far and wide. It is a case this, of an emigration agency conducted on the cheapest and most economical of principles. The free breakfast of humanity in winter is paralleled by the holly's invitation to the birds, only the charity of the plant world is a means to an end, in which respect, let us hope, human almsgiving does not imitate lower nature. This, in brief, is the story of the holly. All the rest is mere detail. A hardy shrub which has fought the battle of life successfully through little increments (not by any means unearned) of strength and vigour, which has developed a toughness of leaf that resists all the violence of the frost, and a berry that is the special type of cheerfulness, when all else is dreary and sad. A wise plant, in truth, the holly. Would that poor humanity in its struggles could always come off as victorious as this prickly-leaved shrub that betokens the time of the world's renewing.

Jean is not curious over her mistletoe. Perhaps she imagines that even science may think fit to descend to nonsense were she to inquire into the history of the Druidic emblem. There are many little passages in life which will not bear the telling, and doubtless Jean's reticence about the mistletoe's history is founded on memories (to be revived, no doubt, at no distant date) connected with a special observance over which the mystical leaves and berries are supposed to preside. To me the mistletoe is infinitely more interesting than the holly. Everything is fair and square with this dark-leaved shrub. It has lived a clean, honest life, and enjoys, like a successful and retired tradesman, the fruits of its past industry. You cannot say the same of the mistletoe. There is something shady about its history. Have you ever realised the attraction which a record of—well, let us say, cheating and swindling, or even crime, has for the majority of men? It is the keen interest we all take in a fight that is responsible for the evolution of this interest. I have seen the faces of men (ay, and, alas! of women also) gleam with eagerness as they followed the course of a murder trial in a court of justice, where the great game of life was being conducted between the law and the culprit, with the judge and jury as arbitrators in the contest.

This is a great human characteristic. We all love to see a mighty game played out, and from the boy in the street who is in the first row when a fight is in progress to the man who follows the chances of the prisoner at the bar, they are all fascinated by the prospect of the great game of "beggar my neighbour." A survival, no doubt, of the days of our savage ancestry when the death struggle betwixt two was the only sport these early men had to enjoy. A survival, too, in us of the later spirit when the Roman Emperors went forth to the amphitheatre to see their gladiators kill and slay one another. And so with all shady things—we may contemn and despise them, but they have their fascination none the less. This is why Jonathan Wild, Jack Sheppard, and Dick Turpin will always be heroes of renown. Mistletoe is a shady plant, I repeat, and for this reason—it is a parasite, and being so, is an unlovely thing in its mode and manner of life. It lives partly at the expense of the oak or apple whence you cut it off. Dropped on its apple host, the mistletoe in its infancy soon shows its predatory instinct. It sends its root into the tree, fastens itself on its host, and proceeds to establish itself as a veritable parasite, sponging on its neighbour for support. The ivy is a different plant, and an honest one withal. It has its own root in the ground, and if, mayhap, by reason of theoretical weakness in its back, it seeks support from other things, it is yet doing little harm, save when, perhaps, its clasp becomes a grip, and it strangles its host. But that is a mere accident. Ivy is not a parasite, for it feeds itself. It is a lodger only at the worst; mistletoe is a lodger and boarder both. Like certain dissatisfied Irishmen, it pays no rent, and claims as a right of tenancy that which at best should only be accorded as a grace.

Mistletoe has green leaves of its own, and this means that it can make so much food for itself from the carbonic acid gas it drinks in from the air. For the rest, it sponges on the tree, and drinks up the sap which its host has elaborated for itself. This is a dishonest life; but if nature has no morals, she still takes out her revenges in a way which justifies us in saying that mistletoe cannot have its cake in the form of an easy life, and eat it also in the shape of a high organisation. Your parasite tends towards deterioration. The battle and striving which have made the holly what it is, independent and flourishing, are unrepresented in mistletoe history. There you have only a record of "mute, inglorious ease." It is a feeble plant, which as the ages pass, will tend to grow feebler still, and to pass into the state and condition represented in the dodder, which is a mere wisp of a plant that has lost even its leaves, and strangles the crops of the farmer like the evil thing it is. But I don't deny that things are flourishing at present with the mistletoe. It is like the company speculator of a certain type who is in his days of fur coats and five-shilling cigars, rooms at the Cecil, a steam yacht, and a mansion in Park Lane. When the evil days come, you will find him in the casual ward of the work-house, unless he is provided by another Government Department with free lodgings (and every attention in addition) in the salubrious surroundings of Dartmoor.

Mistletoe will degenerate as surely as its leaves are green. It is the universal fate of the parasite that it should sink deeper and deeper into the morass of inanimation and sloth. When Christmas dawns a few ages hence, there will be a different mistletoe, probably, seen from that which Jean is tying up so carefully under the hall lamp. I prophesy that its leaves will be the first thing to go the way of all degenerating things, and when this happens, its berries will be neither so large nor so prominent as they are to-day. It may be that tradition will cause even this degenerate plant to be beloved of young men and maidens, but of these things an old fogey may take no account at all. To-day it is a swindling and cheating member of the plant world. Only with a faith born of what one knows of life at large, I leave to the ages to come the work of taking out their revenge.

Jean has finished her decoration, and is as happy as presumably a restless spirit, anticipating the arrival of a certain train, can be. She is still singing of the Paradise of Two, but I go back to friend Omar's version, because, though I am not too ancient for romance, I think the jug of wine and the verses would suit my mood even if the "thou" were absent. Ah! these wildernesses of life! Perchance we all need a "thou" to convert them each into a Paradise, and it may well be that Paradise, even here below, is never modelled or contrived on the single and unattached system.

The choir boys have passed to the church where they are to practise their Christmas anthem.

Through the windows that open on to the lawn you can hear faintly the mellowed notes of the organ and of their praise-song. It is a song of peace—that which of all things is most beloved of weary men, and amid the gathering shadows I sit lulled to rest by the refrain—"Peace and good-will to all—to all, good-will and peace!"

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